Supplemental instruction for improving first-year results in engineering studies

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Many studies have been made on the impact of supplemental instruction in supported courses, with most showing significantly better examination results for students attending supplemental instruction in comparison to those who do not. However, remarkably little attention has been devoted to following up whether the benefits of supplemental instruction reach beyond the course it supports. The present study focuses on the influence of supplemental instruction on the overall academic performance during the first year, for undergraduate engineering students at a Swedish university. The results show that students with average and high supplemental instruction attendance do significantly better than students not attending in terms of overall first-year credit performance. Students with low, average and high prior academic achievement all benefit from attending supplemental instruction sessions. The data also suggests that the transferable effects of study strategies and skills to non-supplemental instruction courses are substantial for attendees, leading to better results in these courses.

Keywords: supplemental instruction; engineering studies; first-year experience

Introduction

Many university programmes experience difficulty in retaining students. At the School of Engineering at Lund University, Sweden, the percentage of matriculating students who successfully complete their MSc engineering degree is about 60% (the MSc engineering degree is the first university degree for the majority of the students – a BSc degree is optional). Many of the students who drop out do so during the first year. Some 79% of the students who began their engineering studies in 2009 returned in the autumn of 2010. Another challenge is timely graduation. Few of the successful students take their degree within the stipulated five years, which is due in part to difficulties adjusting to studies at university level. What difficulties do new students face when entering the School of Engineering? There are many, not all of which are related to their studies:

- The courses are at a higher level and faster pace, thus requiring more in-depth understanding.
- The number of study hours per week, including scheduled hours, increases by roughly 30–40% at university.

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Students’ responsibility for their studies increases. There is less feedback and
guidance from teachers in relation to their studies. Many students are dependent
on state grants for their subsistence, and need to be successful in their studies to
continue to receive these grants.

For many students the social network disappears. They move away, often far
from family and friends, to begin a new life in a different town.

Consequently, it is a tough challenge that awaits new students at the School of Engi-
neering, and therefore it is not particularly strange that many drop out. For a couple
of years now, supplemental instruction has been used on a broader scale to facilitate
the new students’ start. Supplemental instruction was developed in 1973, at the
University of Missouri in Kansas City, to increase student success in ‘difficult’
courses (Hurley, Jacobs, and Gilbert 2006). Supplemental instruction as a concept has
since spread widely and is used at more than 1500 university colleges and universities
in nearly 30 countries (Martin 2008). Supplemental instruction is not just a method but
an attitude to learning, where inner motivation and curiosity are the driving forces, and
where the main emphasis is on self-governing and collective learning (Olstedt 2005).
Supplemental instruction complements the regular studies of a course. The idea
behind it is that learning a subject is enhanced by an exchange of thoughts and ideas
between students. The supplemental instruction sessions are guided by a senior
student. This senior student takes the role of a facilitator and aids clarification of tough
questions within the subject by asking questions, initiating work in small groups, and
coordinating the presentation of conclusions. This senior student attends a training
course in how to be a supplemental instruction leader, and is provided with tools to
use during the sessions.

Supplemental instruction was introduced in 1994 at the School of Engineering at
Lund University as an experimental project to increase student retention and improve
performance in ‘difficult’ courses (Bruzell-Nilsson and Bryngfors 1996). Recently the
overall objective has changed slightly, and the aim today is at bridging the gap
between secondary school and university, in addition to supporting students in ‘diffi-
cult’ initial compulsory courses. The underlying objectives (besides increasing under-
standing of course content) of the supplemental instruction programme include:

- Letting the first-year students take greater responsibility for their own learning in
  an informal collaborative learning environment;
- Stimulating critical thinking and helping students clarify ideas through discussion;
- Moving students away from considering teachers the sole sources of knowledge
  and understanding;
- Being in a network of students with whom you feel comfortable studying and
  interacting socially;
- Getting acquainted with a senior ‘model’ student’s view on successful study
  strategies;
- Developing study skills like note-taking, problem solving and preparation for
  sitting tests.

Since the supplemental instruction programme uses collaborative techniques as a
basis, it also promotes social interaction in an academic environment, which, according
to Tinto (2010), is a recipe to increase retention. So, at least in theory, the supple-
mental instruction programme would increase both student results and student
retention. The objective of the present study is to evaluate the programme with respect to both of these areas, during the first undergraduate year. This is done by addressing the following research questions:

1. To what extent does supplemental instruction increase retention during the first year?
2. How does supplemental instruction affect student results overall during the first year in terms of total course credit production?
3. Does supplemental instruction affect more than the supported course in terms of student results? If so, how pronounced are these transfer effects?
4. Are there differences in how supplemental instruction affects students with different prior academic achievement?

What information on these questions is already available from other investigations elsewhere? Not that much actually. Most attention has been paid to question one. Blanc, DeBuhr, and Martin (1983) and Arendale (2001) considered the re-enrolment rates among students following a semester where supplemental instruction was provided, and found that attendees re-enrolled at a statistically significant higher rate compared to non-attendees. Blat et al. (2001) found similar results when comparing retention rates during promotion from second year to third and third to final years for supplemental instruction students and non-supplemental instruction students.

In an investigation related to question two, Bowles, McCoy, and Bates (2008) found that students participating in supplemental instruction sessions during their first year increased their chances of a timely graduation four years later. A preliminary study by Malm, Bryngfors, and Mörner (2010) at the School of Engineering at Lund University (based on a different and more limited student group than the present study) indicated that the total course credit production during the first year was considerably higher among supplemental instruction participants than those who did not attend sessions. However, the relation between the degree of attendance and first-year course credit production was not investigated.

Research question three, regarding transfer effects from supplemental instruction supported courses, was partly addressed by Gattis (2000, 118), who found ‘effects of fall chemistry supplemental instruction attendance on spring chemistry grade, pointing to long-term retention of information discussed in the supplemental instruction sessions’.

The last research question, on the impact of supplemental instruction on students with different prior academic achievement, has received attention in a couple of studies. Ogden et al. (2003) followed students during the two years after attending a course in political science supported by supplemental instruction. They found that conditional students (on learning support programmes and/or with English as a second language entry status) participating in supplemental instruction had significantly higher short- and long-term outcomes compared to conditional non-participants. These results are in agreement with an earlier study conducted by Ramirez (1997). Here, students in supplemental instruction supported courses from different faculties were followed for a period of four years beyond these courses. Ramirez found that the greatest beneficiaries for both the immediate and the longer term were at-risk students, having significantly greater retention rates than the at-risk non-supplemental instruction users.
The present study could, therefore, provide some valuable new information in the areas the research questions address. In the study, data from 10 MSc engineering programmes during the academic year 2009/2010 was used.

The supplemental instruction programme at the School of Engineering, Lund University

The academic year at the School of Engineering is divided into four quarters (autumn and spring semesters of two quarters each). Each quarter consists of seven weeks of scheduled classes and one week of examinations. A full workload for a student is usually to take two courses each quarter. The supplemental instruction programme is normally attached to compulsory courses which suffer comparatively high failure rates during the first two to three quarters of the first year. The aim of the supplemental instruction programme is to help the new students to adjust to their university studies and get a good start. It is optional for the student to attend supplemental instruction sessions.

For the 10 engineering programmes considered in the present study, all but one have supplemental instruction attached to one common course in the first quarter – Calculus in One Variable. The remaining programme has supplemental instruction attached to a course in Physics. In the second quarter six programmes continue with supplemental instruction attached to the calculus course (Calculus in One Variable is a comparatively large course and runs over either two or three quarters). Three other programmes use supplemental instruction in connection with a course in Linear Algebra, while one programme has a course in Physics supported by supplemental instruction. In the first quarter of the spring semester the number of programmes that have supplemental instruction is reduced to eight, four with supplemental instruction still attached to the calculus course. The other four have supplemental instruction in Linear Algebra, Introductory Chemistry, General Chemistry and Mechanics courses respectively.

In each quarter, two-hour supplemental instruction sessions are offered once a week to each student during weeks two to seven (thus the maximum number of sessions a student can attend is six for each quarter). The sessions are scheduled during normal school hours (8 a.m. to 5 p.m.), so should not conflict with other ‘out-of-school’ activities. Therefore every student should be able to attend supplemental instruction sessions regularly (particularly since there are no tuition fees in Sweden and state grants to students are generous enough to allow them to study full-time: students with family responsibilities receive higher grants to allow them to also study full-time). Based on the attendance from the previous year, 34 supplemental instruction leaders were employed to allow for an average group size of about 10 students per session (experience has shown that groups of this size tend to work best). However, the supplemental instruction leaders were prepared to handle groups of up to 25–30 students so that attendance peaks and/or increased general attendance could be dealt with.

Data used in the study

In the study we have used data on the credits taken by each student during the first year in the engineering programme to compare the student success of supplemental instruction participants to those not attending. Sweden follows the European Credit Transfer System (ECTS), which gives 60 credits for a full year of completed studies.
The engineering programmes at the School of Engineering typically have a study year comprising eight courses worth on average 7.5 credits each. In most courses credits are given for activities such as assignments and laboratory work in addition to examinations. Therefore, the sum credit for the first year used in this study can differ substantially between students, dependent on how well their studies have gone. In the study we have also used data on credits taken in the course Calculus in One Variable in order to isolate the ‘transfer effects’ to other courses. The calculus course is worth in total 15 credits.

In order to examine whether there are differences in prior academic achievement between supplemental instruction participants and non-participants, we have used the grades from Swedish secondary school, both the total grade average and the grade average for mathematics. For this to be comprehensible some insight into the Swedish secondary school system is required: generally it spans three years, and is composed of some 20–25 courses comprising programmes with different orientations (natural science, economics, humanities, etc.). Each student obtains a grade for each course. Besides fail, the grades are pass, good and excellent. When applying to be admitted to university, one does so on the basis of the average grade in all courses (with compensation for different course sizes). Here pass is given the numerical value 10, good is given 15 and excellent 20. This means that the secondary school average pass grade is a numerical value somewhere between 10.0 and 20.0. This value for each student included in this study is used as a measure of his or her previous knowledge. Besides this full grade average in secondary school, we have also used the average grade in the five mathematics courses, as a measure of previous knowledge of special importance for engineering students (applicants to the School of Engineering have to pass at least five courses in mathematics in contrast to those applying to other faculties of the university, who do not require mathematics to the same extent).

Results

Supplemental instruction attendance

The supplemental instruction attendance for first-year students from the 10 engineering programmes, in each of the first three quarters of the academic year, is given in Table 1. In the first quarter 75% of the students attended at least one supplemental instruction session. In the second and third quarter this percentage decreased to 58% and 53% respectively. Likewise the average attendance became successively smaller by quarter, from 49% in the first quarter to 31% in the second quarter and finally down to 29% in the third quarter. The average number of attendees at a session was 12 students in the first quarter (34 supplemental instruction leaders), 8 students in the second quarter (30 leaders) and 8 students in the third quarter (20 leaders). The percentage of students attending all six supplemental instruction sessions in a quarter was 21%, 10% and 7% in quarters 1, 2 and 3 respectively.

Credit production during year 1

In Table 2, student data on credits taken during the first year is given as a function of supplemental instruction attendance. Attendance is divided into four categories: high, average, low and no attendance. The number of students is distributed quite evenly between the four attendance groups. The percentage of students not completing the
first year differs considerably across the categories, from 22% for the non-attendance group down to 3% for the high attendance group. Although it is hard to draw any definite conclusion from this data due to the potential bias of self-selection, it suggests that attendance at supplemental instruction is good for student retention. Credit data for the students who completed the first year clearly shows that a high or average attendance at supplemental instruction sessions leads to considerably higher credit production during the first year. At the School of Engineering the credit production per student during the first year is seen as an important indicator of how many will ultimately take their MSc degree. The goal set by the Board of the Faculty aims at 75% of new undergraduates passing at least two-thirds of the credits given in the first year of study (Lunds Tekniska Högskola 2007). As can be seen in Table 2, there are large differences in the percentage of students achieving this goal, from 90% for the high attendance group down to 43% for the group of students who did not participate in supplemental instruction sessions. These results clearly suggest a great benefit for those attending supplemental instruction sessions in regard to the total credit production for the first year, apart from improving chances of success in the course to which supplemental instruction is attached.

However, measures of prior academic achievement given in Table 2, the average grade in secondary school plus the average grade in mathematics in secondary school, indicate that the supplemental instruction attendees have a higher aptitude, which presumably leads to higher credit production. To minimise this effect we split the students into ‘weak’, ‘average’ or ‘strong’ based on their average mathematics grade from secondary school (this indicator of prior academic achievement has been shown to be slightly better than the average grade in secondary school for predicting student results in engineering studies at the School of Engineering: see Malm 2009). By this procedure we neutralise the effect of differences in mathematics grades between supplemental instruction attendees and non-attendees (the differences in mathematics grades between the weak, average and strong groups were 0.1 or less).

In Table 3 the credit production and percentage of students achieving the School of Engineering goal are given for ‘weak’, ‘average’ and ‘strong’ students as a function of supplemental instruction attendance. In terms of students having completed the first year, the credit production is clearly and significantly higher for high and average supplemental instruction attendees compared to the group of students not attending, which fully agrees with the results from Table 2. The group that benefits the most is the group with ‘average’ prior academic achievement, showing a substantial difference

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### Table 1. Supplemental instruction attendance in quarters 1–3 (of 4) in first-year courses (for 10 engineering programmes) at the School of Engineering at Lund University for the academic year 2009/2010.

<table>
<thead>
<tr>
<th>Quarter</th>
<th>No. of students in courses with supplemental instruction</th>
<th>Average attendance (%)</th>
<th>No. of supplemental instruction sessions (% of students attending)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>816</td>
<td>49</td>
<td>0 1 2 3 4 5 ≥6</td>
</tr>
<tr>
<td>02</td>
<td>796</td>
<td>31</td>
<td>0 1 2 3 4 5 6</td>
</tr>
<tr>
<td>03</td>
<td>581</td>
<td>29</td>
<td>0 1 2 3 4 5 6</td>
</tr>
</tbody>
</table>
of more than 18 credits between the group with high supplemental instruction attendance and the group of students not attending. The group with ‘weak’ prior academic achievement also gains substantially in terms of credit production by attending supplemental instruction sessions. Again the difference is considerable between the two opposite groups in terms of supplemental instruction attendance, being more than 14 credits. The group with high grades in mathematics from secondary school also benefits from attending supplemental instruction in terms of credits taken in the first year, though less so, as the group as a whole does well and is relatively close to the full yearly workload of 60 credits.

The group with low supplemental instruction attendance does not show significant differences in credit production compared to the group not attending, with the exception of the group with prior ‘average’ academic achievement, which does significantly better than the corresponding group of non-attendees. This is probably not unexpected as it presumably takes a period of time attending supplemental instruction sessions to reap the benefits in terms of increased general credit production.

These observed differences in credit production become enhanced when comparing how different attendance groups cope with the School of Engineering goal of a minimum of 40 credits during the first year. For the groups with ‘weak’ and ‘average’ prior academic achievement there are huge differences in the percentage of all first-year students who pass 40 credits or more, a difference of about 55–60% between the group with high supplemental instruction attendance and the group of non-attendees. Moreover, in this case, the difference within the group of ‘strong’ students is not as pronounced due to a generally high achievement in credit production. But the general tendency is the same – if you attend supplemental instruction sessions with an average or high frequency, you will have a better chance of reaching the School of Engineering goal. A final interesting note is that ‘weak’ students with high supplemental instruction

### Table 2. Student data on credits taken during the first year as a function of supplemental instruction attendance.

<table>
<thead>
<tr>
<th>Attendance (no. of supplemental instruction sessions)</th>
<th>None (0)</th>
<th>Low (1–5)</th>
<th>Average (6–10)</th>
<th>High (≥ 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of first-year students</td>
<td>165</td>
<td>254</td>
<td>221</td>
<td>198</td>
</tr>
<tr>
<td>Average grade in secondary school</td>
<td>17.0</td>
<td>17.4</td>
<td>17.7***</td>
<td>18.0***</td>
</tr>
<tr>
<td>Average grade in mathematics in secondary school</td>
<td>16.9</td>
<td>17.1</td>
<td>17.4*</td>
<td>17.7***</td>
</tr>
<tr>
<td>Percentage of students not completing the first year</td>
<td>22%</td>
<td>15%*</td>
<td>8%***</td>
<td>3%***</td>
</tr>
<tr>
<td>Average number of credits taken during the first year</td>
<td>42.1</td>
<td>45.3</td>
<td>51.9***</td>
<td>55.6***</td>
</tr>
<tr>
<td>Percentage of all first-year students achieving the School of Engineering goal of at least 40 credits during the first year</td>
<td>43%</td>
<td>57%*</td>
<td>78%***</td>
<td>90%***</td>
</tr>
</tbody>
</table>

The data is taken from 10 MSc engineering programmes during the academic year 2009/2010. Statistically significant differences using an independent t-test (two-sided distribution) or chi-square test with $p < .05$, $p < .01$ and $p < .001$ compared to the group of students not attending supplemental instruction are indicated with *, ** and ***.
The above results clearly indicate that, on average, supplemental instruction attendees benefit greatly in terms of credits taken during the first year, and, further, that the more students attend supplemental instruction, the more credits they take. But one may ask how much is due to the likelihood that supplemental instruction attendees perform better in the course that is supported, and how much is a transferable effect to other courses, presumably due to better study strategies and skills obtained through supplemental instruction, and the potential increase in self-esteem and confidence by participation in supplemental instruction sessions? Such an investigation is not easily undertaken for all 10 engineering programmes considered here, since most programmes have supplemental instruction in more than one course. However, four programmes have supplemental instruction limited to one course only, Calculus in One Variable, making it much easier to divide the observed increase in first-year credit production for supplemental instruction attendees into a course-related part and a transfer effect-related part.

The credits taken in Calculus in One Variable, and totally for the first year, are given in Table 4. As in Table 2, the number of students is distributed quite evenly between the four attendance groups. The percentage of students not completing the
first year again differs considerably, from 24% for the non-attendance group down to 0% for the high-attendance group. The gains in credits taken in the course Calculus in One Variable (worth in total 15 credits and consisting of either two or three modules) are considerable if you attend supplemental instruction. For example, the students with high attendance take on an average 4.8 credits more in the course as compared to non-attendees. The benefits of being a student with an average or high supplemental instruction attendance when it comes to total credits taken in the first year is clear, and compares well to the figures in Table 2.

It is most likely that the results for the student group with high supplemental instruction attendance are overestimated due to a slightly higher prior academic achievement for the group (not statistically significant, however), which presumably leads to better results. However, this effect is marginal considering the limited effect when ‘neutralising’ the influence of prior academic achievement between Tables 2 and 3. If we then proceed to reduce the total credits taken by the credit gain due to supplemental instruction in the calculus course, the benefits of being a supplemental instruction attendee are still substantial (although only the higher rate of attendance is statistically significant). The relative first-year credit ‘gain’ for supplemental instruction attendees is also considerable for courses not supported by supplemental instruction. These findings clearly suggest that the transferable effect to other courses of improved study strategies and skills, combined with a probable increase in self-esteem and confidence, leads to a significant overall improvement in student results.

Table 4. Student data on credits taken in Calculus in One Variable (worth 15 credits) and in total during the first year as a function of supplemental instruction attendance.

<table>
<thead>
<tr>
<th>Attendance (no. of supplemental instruction sessions)</th>
<th>None (0)</th>
<th>Low (1-5)</th>
<th>Average (6-10)</th>
<th>High (≥ 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of first-year students</td>
<td>75</td>
<td>109</td>
<td>86</td>
<td>78</td>
</tr>
<tr>
<td>Average grade in mathematics in secondary school</td>
<td>16.1</td>
<td>16.0</td>
<td>16.2</td>
<td>16.9</td>
</tr>
<tr>
<td>Percentage of students not completing the first year</td>
<td>24%</td>
<td>16%</td>
<td>6%*</td>
<td>0%***</td>
</tr>
<tr>
<td>Average number of credits taken in the course</td>
<td>8.4</td>
<td>8.1</td>
<td>11.4**</td>
<td>13.2***</td>
</tr>
<tr>
<td>Calculus in One Variable for students completing the first year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in credits taken in the course Calculus in One Variable compared to the group not attending supplemental instruction</td>
<td>–</td>
<td>–0.3</td>
<td>3.0</td>
<td>4.8</td>
</tr>
<tr>
<td>Average number of credits taken during the first year for students completing the first year</td>
<td>41.7</td>
<td>40.8</td>
<td>49.8**</td>
<td>53.7***</td>
</tr>
<tr>
<td>Average number of credits taken during the first year reduced by credit ‘gain’ in the course Calculus in One Variable due to supplemental instruction</td>
<td>41.7</td>
<td>41.1</td>
<td>46.8</td>
<td>48.9**</td>
</tr>
</tbody>
</table>

The data is taken from the four MSc engineering programmes where supplemental instruction is attached only to the calculus course. Statistically significant differences using an independent t-test (two-sided distribution) or chi-square test with $p < .05$, $p < .01$ and $p < .001$ compared to the group of students not attending supplemental instruction are indicated with *, ** and ***.
Discussion

What are the consequences of the above results? First of all, participation in supplemental instruction sessions leads to fewer engineering students dropping out during the first year, which is consistent with previous findings (Arendale 2001; Blanc, DeBuhr, and Martin 1983; Blat et al. 2001). If we, based on the retention percentages presented here, compare scenarios with and without a supplemental instruction programme at the School of Engineering, the number of students dropping out during the first year is almost halved by using the present supplemental instruction programme set-up. Furthermore, the supplemental instruction attendees are considerably more effective in taking course credits during the first year, which probably has a pronounced impact on timely graduation. In the results presented above, frequent supplemental instruction attendees take one-third more course credits during the first year than students who do not attend supplemental instruction, which corresponds to almost a quarter of a year of completed studies. Also, a more successful first year will most likely further reduce attrition. For supplemental instruction attendees, a large portion of the higher course credit production can be attributed to transfer effects from supplemental instruction supported courses to other courses, in terms of better study strategies and skills, self-esteem and an established network of study partners. These transfer effects are also likely to benefit supplemental instruction participants in courses after the first year, making them more efficient in terms of timely graduation, which, as mentioned, has been suggested in the study by Bowles, McCoy, and Bates (2008).

In order to determine the exact benefits of supplemental instruction in terms of how it changes the percentage of students who take their engineering degree, and how it affects timely graduation, a longitudinal study is required. But it is quite likely that student results during the first year have a significant influence on these outcomes. Therefore, the results achieved by using supplemental instruction at the start of engineering studies at the School of Engineering at Lund University seem very encouraging.

Prior academic achievement in secondary school does matter when comparing how many course credits a student takes over the first year of engineering studies at the School of Engineering. Based on the average grade in mathematics in secondary school, students with high prior academic achievement completing year one take 92% of the given course credits during the first year, while students with average or low prior academic achievement take 81% and 68% respectively. However, students that did not do as well in secondary school can offset these differences by attending supplemental instruction sessions. For instance, students with low or average prior academic achievement, but with a high supplemental instruction attendance, do as well as students with high prior academic achievement who did not attend supplemental instruction, in terms of course credit production over the first year. This clearly indicates the potential of supplemental instruction as a support programme.

Interestingly, however, the supplemental instruction sessions at the School of Engineering are not seen among students as extra sessions for ‘weaker’ students. There is actually an over-representation of students with higher aptitudes attending supplemental instruction. The reason for this we do not know. Perhaps students who did do well in secondary school better recognise the need for improved study strategies and skills to cope with studies at university level. The consequence, however, is that we need to get better at informing students of the potential of supplemental
instruction to affect their study results, so that the representation of students with low prior academic achievement improves.

Can these results from supplemental instruction be generalised beyond the engineering programmes at Lund University? The answer is yes, definitely, with regard to the portion of increased course credit production that comes from students performing better in supplemental instruction supported courses (although the magnitude is likely to differ from case to case, dependent on how the supplemental instruction programme is set up, the subject, the education year, etc.) This has been shown repeatedly in literature independent of course subject. It also seems reasonable to expect that the transfer effects from supplemental instruction supported courses to other courses, as experienced in the present study, will occur in other educational areas as well. However, one can expect variation in how great the transfer effects will be, not just due to differences in how the supplemental instruction programme is set up and differences between universities and countries, but also due to educational programme structure and area. Here the degree under consideration consists of compulsory courses over the first three years. This means that the peer group and network of study partners obtained in supplemental instruction remains the same over a long period of time, and that conditions for transfer effects to other courses are optimised. One can also expect that the main skill improved through supplemental instruction – problem solving in an engineering/natural science context – is central in most other non-supplemental instruction supported courses over the first year, which again favours transfer effects. It may not always be the case, however, that the skills developed through supplemental instruction in one course are so readily applicable to other courses.

Consider the costs associated with supplemental instruction in the present case – have they been justified from an economic standpoint? Costs for 34 supplemental instruction leaders, venues for sessions, one supervisor and office supplies amounts to approximately €100,000. Gains with supplemental instruction are primarily based on a higher credit production (undergraduate and graduate studies at Swedish universities are partly funded on student performance and expressed in credits produced per year by each student). In the present case, with 198 students with high supplemental instruction attendance and 221 students with average attendance producing 13 and 10 more credits respectively than non-supplemental instruction attendees, the total gain can be estimated to be approximately €300,000. Thus, from a purely economic standpoint, the investment is sound. For universities funded by tuition fees, the expected financial rewards from a supplemental instruction programme are likely to be considerably higher. One example from the University of Central Florida published by Congos (2001), based on tuition fees from students not dropping out due to participation in the supplemental instruction programme, estimated that the gain obtained exceeded costs more than tenfold. Thus, supplemental instruction would generally appear to be a wise investment for universities experiencing retention problems.

In terms of first-year credit production, engineering students with average and high supplemental instruction attendance do significantly better than students not attending supplemental instruction. Students with low, average and high prior academic achievement all benefit from attending supplemental instruction sessions, but the benefits are more pronounced among the first two categories. The data also suggests that the transferable effects of study strategies and skills to non-supplemental instruction courses are substantial for supplemental instruction attendees, leading to better results in these courses too.
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