Engineering Students' Experiences of Supplemental Instruction: A Case Study

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This article explores Engineering students' experiences of supplemental instruction (SI). SI is a student engagement approach that is meant to provide 'support' to students with the aim of improving pass rates. The sample population used in the study was constituted from the 2009 Chemical Engineering cohort. From this broad sample, the performance scores of 15 regular SI attendees were tracked over a period of three semesters. Qualitative data was also collected through focus-group discussions with six of the regular attendees. The data was analysed using an interpretive methodology. The findings from the study suggest that SI has the potential to provide positive learning spaces for students, enabling them to effectively engage with learning materials. However, the results also underscore the need to modify the programme to ensure that students do not become overly reliant on it.

Keywords: supplemental instruction, experiences, engineering students

Introduction

The notion of student engagement has been around for some time, though conceptual approaches to it differ. Scholars such as Jean Piaget (1977) and Vygotsky (1978) have been credited with advancing the idea, and their work has been influential in the development of a number of approaches that encourage collaborative learning. These approaches include mentoring, peer tutoring, and supplemental instruction (Falchikov 2001). This article is mainly concerned with the approach called supplemental instruction (SI),

which was introduced at the Faculty of Engineering in the University of KwaZulu-Natal (UKZN) in 2008. This project was conceived and enabled through a Faculty grant from the Department of Higher Education and Training to improve throughput and curb attrition rates.

The fact that students under-perform in higher education in the South African context has been well documented in a number of research projects (see for instance Du Toit & Roodt 2009; Scott, Yeld & Hendry 2007; Shackleton, Riordan & Simonis 2006). In 2008, the former Minister of Education, Naledi Pandor, indicated that only 50% of students who enter higher education actually graduate (Pandor 2008). However, it is believed that attrition rates are more severe in engineering education (Case 2006; Shackleton *et al.* 2006).

A number of reasons have been advanced to explain this attrition: the dominant one being the history of disadvantage, which was brought about by the apartheid government. However, reasons peculiar to engineering include the high student–lecturer ratio as a result of the brain drain that has seen a number of trained engineering professionals leaving the country (Du Toit & Roodt 2009) as well as 'limited knowledge' in science and mathematics (Case 2006; Jacobs & De Bruin 2010; Nel 2010). There is also the belief that engineering faculties have a 'sink or swim' policy, which can be challenging to students (Shackleton *et al.* 2006). This implies that there is limited, if any, support to enable these students to gain epistemological access. Consequently, students are limited in terms of opportunities to participate in meaningful ways in their education. If this is the case, then classrooms become contested spaces in which only the fittest and strongest survive.

The issues highlighted above pose challenges for pedagogy, with the main problem being the fact that the way the teaching and learning context is constructed has implications for student learning. Broadly speaking, the issues suggest that the nature of the learning context impacts significantly on the process of learning (Smith 1999). It is in line with this concern that the extent to which SI as an academic development programme can provide engineering students with opportunities to participate in a meaningful way in their own learning is explored.

There are five main sections in this article. The first section focuses on literature on SI, describing what the concept and its main issues entail. The second part sets out the theoretical framework informing this study. The

third section presents the context and the methodology that was used in this study. The fourth section discusses the findings to establish the extent to which SI can provide students with opportunities to meaningfully participate in their own learning. The last section is the discussion in which the findings are synthesised.

What is Supplemental Instruction?

SI was developed in 1973 at the University of Missouri-Kansas City 'as a response to a need at the institution created by a dramatic change in the demographics of the student body and a sudden rise in student attrition' (Arendale 2002: 4). Since then, SI has been implemented in many institutions across the world under various labels, such as peer-assisted study sessions (PASS) in New Zealand and Australia (Van der Meer & Scott 2009) and peer-assisted learning (PAL) (Topping & Stewart 1998). Although SI was only adopted at the UKZN in 2008, the history of its use in South Africa dates as far back as the 1990s (Voster 1999). Therefore, it is not new in this context.

SI is a peer-assisted learning programme that is targeted at 'high-risk' courses and not 'high-risk' students (Arendale 1994; 2002). It is also a two-tiered programme that seeks to facilitate understanding of course content, while at the same time encouraging students to develop better learning skills and strategies and meta-cognitive skills. Meta-cognition which involves 'knowledge about knowledge' is a reflexive ability that helps students to understand their own learning processes (Biggs 1985; Cross & Steadman 1996; Jackson 2004). Given this background, the value of meta-cognitive skills in the learning context can therefore never be overemphasised. When students are aware of their own learning, and especially how they learn, they become better able to manage their own studies. Within the SI framework, students who have excelled in a targeted SI module are trained[1] as SI leaders. The role of the SI leader is to model effective learning strategies that students can adopt in a specific course. The SI leader also acts as a facilitator in the collaboration of learning with

[1] SI leaders are trained by qualified supplemental instruction supervisors in facilitation methods.

students during SI sessions (Arendale 2002). In this sense, SI is a learning community made up of students and has the potential to increase student engagement.

Studies on Supplemental Instruction

The literature on SI is concerned with foregrounding the benefits of SI by establishing a causal effect between SI attendance and pass marks (Bowles, McCoy & Bates 2008; Gardner, Moll & Pyke 2005; Marra & Litzinger 1997; Wolfe 1987). These benefits have included economic benefits (Zerger, Clark-Unite & Smith 2006), benefits to the faculty (Voster 1999; Zerger *et al.* 2006), benefits to the institution (Voster 1999; Zerger *et al.* 2006) and benefits to the student. With regard to economic benefits, advocates have argued that SI is 'helpful for institutions' budgets because student retention rates are higher' (Zerger *et al.* 2006: 66). These economic benefits translate into institutional benefits; hence, SI promotes the service component of the institution. While the literature suggests that the faculty also benefits from SI training in collaborative teaching techniques, not many empirical studies have explored this. As far as students are concerned, the literature indicates that when students attend SI regularly, they learn material more effectively, which leads to the improvement of their grades (Gardner *et al.* 2005; Marra & Litzinger 1997; Zerger *et al.* 2006). This is because SI is believed to develop students' meta-cognitive 'skills', making them independent learners in the process (see Arendale 2002). In light of this, SI is well placed to improve teaching and learning, especially in a country in transition such as South Africa.

Based on all these benefits highlighted in the literature, it is not surprising that SI has been incorporated into programmes such as mathematics (Gardner *et al.* 2005), medicine (Hurley, McKay, Scott & James 2003), economics (Worthington, Hansen, Nightingale & Vine 1997) and biology (Shaya, Petty & Petty 1993) internationally. In the South African contexts, the Nelson Mandela Metropolitan University has also incorporated SI in all its disciplines and has been established as the national office for coordinating SI in the country. Notwithstanding the value placed on SI by advocates, there has been little scrutiny of the causal effect between pass rates and SI attendance. There are other factors that could impact on student

success, such as the curriculum as well as socio-economic or historical factors. While I took the focus on pass rates as the starting point for analysis of SI efficacy in the study on which this article is based, I also extended the scope to include an analysis of the effect of SI on the learning context. I believe that, while pass rates are a relevant measure of efficacy, there are also benefits in measuring the extent to which SI can improve student participation in their discourse community.

Theoretical framework

Approaches to understanding the teaching and learning context can be largely classified into two categories: On one side, there are those who see learning as contingent on individual characteristics as '[a] process by which a learner internalizes knowledge' (Lave & Wenger 1991: 47). On the other side, there are those who see learning as embedded in and a product of socio-cultural practices (Gee 2003; Lave & Wenger 1991). This study draws from the latter of these categories and sees learning as a shared responsibility between students and others in their learning community. Consequently, it draws from a social view of learning known as situated learning (see Lave & Wenger 1991), which also suggests that people learn from observing other people in their contexts (Smith 1999). In this sense, learning occurs if it is embedded in the socio-cultural context in which it will be used; students should therefore engage in purposeful activities in shared practices of the community of practice. Thus, SI fits naturally within this theoretical framework, given its main objective, namely to enrich learning outcomes by increasing student interaction and engagement.

Context

At UKZN, SI is offered by the Academic Support and Advancement Programme (ASAP), which is affiliated with the Faulty of Engineering. The mission of ASAP is to offer academic support to all students within the faculty to facilitate academic progress. ASAP runs various student- and staff-development workshops, SI sessions, tutoring sessions, writing programmes and one-on-one consultations with the various academic development officers affiliated with the five schools in the faculty.

Methodology

This study was conducted over three semesters at the UKZN and the sample population was constituted from the 2009 Chemical Engineering cohort. These students were enrolled in three gatekeeper courses, namely Chemical Engineering Principles 1 in Semester 1 of 2009, Chemical Engineering Principles 2 in Semester 2 of 2009 and Mass and Energy Balances in Semester 1 of 2010. These three courses are typical 'high-risk' courses (as defined in the SI literature, see Arendale 2002, for instance) in the School of Engineering with a combination of a high failure rate and large classes. Furthermore, success or failure in these courses has implications in terms of progress, given that they are pre-requisites to a number of the Chemical Engineering modules.

I decided to focus on attendance patterns in Semester 1 of 2009 for this cohort of students. The focus on attendance patterns is consistent with the literature on the effectiveness of SI (see for instance studies by Arendale 2002; Bowles *et al.* 2008; Van der Meer & Scott 2009). From this data, 15 frequent attendees were identified and their performance was tracked in the three semesters between January 2009 and June 2010. The analysis of their pass marks was done initially to establish whether SI had an effect on their academic performance. The regular SI attendees were then tracked in the second semester of their first year in a follow-up course, Chemical Engineering Principles 2, as well as in the first semester of their second year in 2010, in Mass and Energy Balances. Qualitative data were also collected through focus-group discussions with six of the regular SI attendees. This information was used to complement the data on pass rates and SI attendance in order to gain an insider perspective of reasons for attending SI. This brings me to the next section, which explores the findings of this study.

Findings

The analysis of the data revealed a number of issues related to both the literature review and the theoretical framework. These are as follows:

- Regular SI attendees performed well in all their modules over the three semesters.

- SI sessions can create learning spaces that encourage participation from students.
- SI leaders helped develop students' confidence.

However, the fourth finding below challenged the theoretical understanding on which SI is built, as reported in the literature surveyed in this article, namely:

- SI can create overreliance on support.

Supplemental Instruction Attendance Patterns

In the context of this study, a student who attended at least one session was considered an SI attendee, while a student who attended at least five sessions through the semester was regarded as a regular attendee (see Table 1 below). Two SI sessions were scheduled per week over a period of 10 weeks in each semester. However, students were to attend only one of the two sessions; thus, 10 attendances were possible for each student. Nonetheless, some of the students attended both sessions each week; thus, for these students more than 10 sessions were possible.

Table 1: SI Attendance Patterns

Attendance patterns			
0 times	1–4 times	5–9 times	10+ times
45	35	13	2

The results from the SI attendance for the first semester of 2009 indicate that 50 of the 95 students taking part in the study (i.e. 52%) attended SI at least once during this semester. However, a closer analysis also reveals that 35 (37%) of these students attended less than 4 times, 13 (14%) between 5 and 9 sessions, while only 2 (2%) attended 10 or more sessions. Forty-five students (47%) did not attend any SI session. This means that only 15 (16%) students in this cohort regularly attended SI sessions. Though non-attendance was not the focus of this study from the onset it became necessary to explore it in light of these findings. During informal discussions with students, time was indicated as the main reason why most of the students could not attend SI

sessions. However, what I found difficult to understand was that students from the first-year cohort, who were not repeating any courses at that time were not attending SI sessions, while other students from the same group were making the time to attend. A number of explanations can be given for this. First, it can be attributed to issues of commitment and dedication as well as taking responsibility for their own learning – aspects that seemed to be lacking in many of the students. Second, there is a possibility that many students perceive additional tuition negatively, as an indication that they are perhaps not 'smart' enough. Given that there was no data to substantiate these claims at the time of writing this article, these explanations remain speculative and an issue for further exploration.

From analysing this dataset on SI attendance and reasons for attending or not attending, it made sense to further sample the 15 students who were regular attendees in the first semester of 2009 to explore their experiences of SI. These regular attendees turned out to be largely African. It is also important to reiterate that this was not planned from the outset, but it became apparent as the analysis evolved that I would get rich and fine-grained data from analysis of these few students, given they were the only ones with sustained attendance patterns.

Pass Rates

An examination of the pass rates of regular SI attendees (see Table 2 below) resonates with the available literature (for example Arendale 2002; Bowles *et al.* 2008) on the value of SI in improving student performance. The results of the SI in the first semester of 2009 correspond favourably for the 15 regular attendees who had a 100% pass rate in Semester 1 of 2009. In Semester 2, 14 out of the 15 students attended SI regularly and again all 14 (100%) passed. In Semester 3, only 8 of the 15 students attended SI regularly. From these, five passed their examinations with marks ranging from 51% to 73%, while two managed to make it to the supplementary examinations. Only one student from this group did not progress to the next module, Thermodynamics 1. With regard to the other seven regular attendees who did not turn up for SI in Semester 1 of 2010, only two passed their examination the first time, with one passing the supplementary examination and the rest failing to meet their progress requirements for this module.

Table 2: Pass Rates of Regular Attendees

Category	Semester 1, 2009	Semester 2, 2009	Semester 1, 2010
Regular attendees	15 out 15 attendees passed (100% pass rate)	14 out of 14 attendees passed (100% pass rate)	6 out of 8 attendees passed (75% pass rate)

Could these students have progressed without SI? Possibly, but the data from the interviews with some of these students, as revealed in sections to follow, indicate that SI was helpful in their passing because it taught them not only how to study, but also taught them higher-order thinking skills that they had not been exposed to. They also claimed that they adopted these strategies in studying for their other modules. These findings lend support to the literature in which the development of higher-order thinking skills is viewed as the core of learning (see for instance Arendale 1994 2002; Cross & Steadman 1996). Furthermore, evidence of the efficacy of SI in helping these students is revealed in their sustained attendance of SI. A closer look at this data reveals that the majority of the students (10 out of 15) who attended SI frequently have all met their progress requirements.

While the analysis above seems to suggest a causal effect between frequent SI attendance and pass rates, I am neither overlooking the fact that there are some factors that can potentially affect academic performance, nor am I unaware of the fact that the number of regular SI attendees in this sample is too small to make any conclusive correlations. My main concern, however, was to understand the experiences of this group of students who consistently attended SI, and to examine what worked for them in SI. To answer this question, I first explore their reasons for attending SI, followed by their perceptions of what worked for them.

Reasons for Attending Supplemental Instruction

The analysis of the interview data revealed a number of reasons to explain why this group of students consistently attended SI. These reasons can be classified into two broad categories, namely the creation of a social learning space and the enhancement of confidence. However, the difference in the learning environment provided in both SI sessions and lectures figured more in students' responses.

Creation of a Social Learning Space

Students indicated that in their first year of study, they felt afraid and intimidated to ask any questions in the lectures. This is not surprising for first-year students, who are often confounded by the transition from high school to university. For this reason, it is not surprising that they found the approach that was used in SI sessions friendlier and more conducive to learning than the one used in the lectures. This is captured in the following excerpt:

> *As a first-year student, I wasn't comfortable to ask lecturers questions in class. I felt intimidated in large classes. But in SI, I was confident enough to ask questions. (C1)*

This was also confirmed by another student, who said:

> *I was afraid to ask any questions during lectures. (C2)*

A PhD study by Paideya (2011) also came to the same conclusion, namely, that SI can create a positive social learning space. In the current study, all six students unanimously felt that SI presented them with a friendly learning environment, confirming the fact that meaningful learning is a product of socio-cultural practices (Lave & Wenger 1991), as outlined in the theoretical framework in this article. They made comments like 'The atmosphere was free'; 'SI is a "free zone"' and 'You get more attention in SI'. A number of reasons can be given to explain why students felt free to ask questions in the SI sessions. In the first instance, SI leaders are fellow students; therefore, there are no power issues resulting from age differences and positionalities. The power asymmetries that exist between lecturers and students as well as language barriers, especially for African students, affect students' self-esteem and confidence, thus they naturally avoid consulting with their lecturers. This potentially makes SI leaders more approachable than lecturers; hence, there was more participation from these students during SI sessions than there was during lectures. Another student was more explicit about the differences in the approaches used in lectures and in SI:

> *[SI is] more personal than lectures, in that in lectures, the lecturers have to deal with a class full of people and the lecturer has a certain schedule that he has to stick to, whereas in SI, it is possible to spend time on certain problems that an individual or a group is having trouble with. (C3)*

Another student also made an interesting comment related to teaching approaches in the lectures:

> *I was able to understand content better in SI. Lecturers sometimes go fast, and even when you ask questions they just repeat the same things in the same way, not realising that if you did not understand it the first time, you will still not understand it if it is repeated in the same way. In SI you can ask questions and get clarity. (C4)*

The above comment is especially consequential for pedagogic practice and conjures up questions like 'Do academics consider the implications of their practice and how such practice can lead to the frustration of students, as revealed in the above excerpt?' In terms of the situated learning theoretical framework used in this article, the finding suggests that learning in this context takes on an autonomous model and is not a shared responsebility between the lecturer and the student (see Gee 2003; Lave & Wenger 1991). Scholars writing in engineering education have also suggested that there is neglect of teaching approaches and discourse in engineering curricula because subjects are treated as bodies of knowledge with little attention being paid to how students process or acquire that knowledge (see for instance Allie *et al.* 2010; Jacobs 2010). This is a crucial issue that needs to be addressed if the teaching and learning context is to be improved. Thus, just like the SI model is conceptualised, there is a need for collaboration between SI practitioners and mainstream academics in developing teaching/facilitation techniques that encourage meaningful learning.

Essentially, for these students, SI provided a space in which they could negotiate their challenges of transition to university, fears of asking questions and the need for personal attention. In the SI learning context, they could engage with learning material more effectively in the space created by SI.

Enhancement of Confidence

The second category of reasons for attending SI that emerged from the interviews with the students was related to confidence. Because this group of students managed to pass all their modules and progressed well over the three semesters, their confidence levels were raised. They now felt they could handle the curriculum and could progress well. Some of the students continued to attend SI because of the benefits they experienced over the three semesters. However, some of the students felt that they had acquired the needed skills to make it on their own. For this reason, they felt the scaffolding provided by SI had managed to equip them with the necessary skills to handle the curriculum.

> *SI leaders have gone through the module, they know the challenges that you face and how you can better study for that module, so they help with tips. (C5)*

Thus, students learnt through observing and interacting with others. Other comments related to confidence included:

> *SI leaders instilled confidence. When you are not clear about a concept and you are afraid, they encourage you. (C6)*

And

> *I never used to ask questions in class when I was in first year. But now I am used to it because that is what we do in SI and I sometimes ask lecturers in class. (C7)*

With improved confidence comes participation; therefore, the situated context in which students engaged in SI encouraged their learning. Generally, the findings indicate that SI was beneficial for these students. Though a causal effect could not be conclusively established between SI attendance and pass rates, what is clear is that SI was useful in helping students develop learning strategies as well as take ownership of their own learning. The next section discusses what did not work for the students.

What did not Work for the Students in Supplemental Instruction?

While most of the comments from students indicated that SI was beneficial in terms of the categories identified above, they made comments that indicated that class management was sometimes a problem during SI sessions. There was also an indication in their comments that they had become over reliant. While the students did not see this over reliance as an issue, I found it problematic for a number of reasons, as discussed in the sections to follow.

Classroom Management

Although the students in this sample felt that SI was generally beneficial for them, they also indicated that SI sessions were noisier than lectures, mostly because the SI leaders had limited power to control unruly students. This can be expected, given that the SI leaders are also students. Consequently, there could be a tendency for students to take these leaders for granted. In this regard, there is a need for ongoing support for SI leaders in class-management strategies.

Reliance on Supplemental Instruction

The six students interviewed in this study are now in the third year of their Chemical Engineering degree. SI is not offered in any of the modules that they are taking because the pass rates in those modules have always been high. Yet, they all expressed dissatisfaction at this, as they felt SI was still relevant to them. Some even suggested that they needed SI in their fourth-year modules, and expressed their concern with failing given the unavailability of SI. This, they maintained, had to do with the teaching style in lectures, which they felt did not adequately encourage learning, as revealed in comment C4 above. With this in mind, it seems as if these students had relied heavily on SI over the first two years of their studies, to the extent that it has become a 'crutch' for them to lean on. This is not the purpose of situated learning. Situated learning is meant to facilitate participation and independent learning. This overreliance on SI also presents a paradox, in which the efficacy of SI in promoting independent learning is

brought into question. Interestingly, students who gleaned study tips from SI leaders and who also claimed that their confidence had improved as a result of SI attendance (see comments C5, C6 and C7), still found it difficult to cope with their studies in modules in which SI was not offered. However, anecdotal information from these students and some who were not necessarily part of the sample revealed that students perceive SI as a substitute for lectures. This is a possibility that is dangerous and that can potentially make students abandon their lectures in favour of SI. This is neither in line with SI principles nor is it acceptable in the university.

Discussion

The data presented above indicate the efficacy of SI in providing positive social spaces that encourage collaborative learning and where students can effectively mediate knowledge. These spaces also enhance confidence in students to ask questions. While the literature on SI widely acknowledges that SI can benefit students in terms of improving their academic performance (Bowles *et al.* 2008; Gardner *et al*. 2005; Mara & Litzinger 1997; Zerger *et al.* 2006), the findings of this study incorporated issues of 'learning spaces'. The PhD study by Paideya (2011) also lends some support to these findings and suggests that SI as an academic intervention privileges social interaction in the development of meta-cognitive strategies. This resonates well with Lave and Wenger's (1991) socio-cultural theory, where learning is perceived as a socio-cultural activity in which social agents construct knowledge together through collaboration and participation. The relationship between students and the SI leader also seemed to confirm the theoretical construct privileged in this study; hence, students felt freer and more comfortable dealing with SI leaders than they did with their lecturers. In this sense, a programme such as SI is well positioned to address the issue of power and positionality in that it makes use of peers, removing the power asymmetries between students and lecturers that characterise educational practice. Once power is removed from the educational context, students see themselves as equals and they are then in a better position to learn without fear of intimidation or ridicule. This was indicated as one of the learning transformations that occurred for the students surveyed in this study.

However, in spite of the positive learning context provided by SI and

the availability of literature on teaching approaches, what remains in the classrooms is in essence an autonomous model in the teaching and learning relationship between students and their lecturers. Some of the comments from students indicated that there is no consideration by academics for the way in which students process knowledge (see comment C4). This was indicated as the reason why students required SI in most of the modules.

The overreliance on SI is also an issue that needs to be addressed. Could it be possible that there is dissonance between SI principles and actual practice? If students consistently feel they need to be supported, even after attending SI in three modules, is it possible then that SI is no different from the rest of the academic support programmes that have been proved to be inefficient in terms of providing students with epistemological access (see Boughey 2005)? Although there was not enough evidence in this study to make a conclusive argument, this assumption suggests a compelling motivation for future research.

With regard to pass rates, while the data indicate a correlation between regular attendance and a pass mark, a simple causal effect could not be established. I am aware that there are other factors that could potentially account for this success, for instance student agency and lecturer input or socio-historical factors. Therefore, resulting discrepancies may not be intended, leaving some emphases in this study open to speculation. This becomes a major limitation of this study and an issue for subsequent exploration.

Conclusion

The aim of this article was to explore engineering students' experiences of SI. These experiences are analysed using the theoretical constructs on which SI is based as revealed in the literature as well as a socio-cultural view of learning. The findings suggest the following:

- Creating learning environments that offer students an atmosphere that emphasises care and respect and that enhances interaction can influence student performance as well as develop an interest in engineering education.

- SI can potentially enhance students' confidence in their learning and develop the study skills necessary to handle the curriculum.

This is particularly true for the group of students that was interviewed in this study, whose performance over the three semesters was impressive and consistent. However, the results also show that SI can potentially create overreliance on support; thereby preventing students from becoming independent learners. This is a concept that has not been explored in the literature on SI. Nonetheless, this was a small-scale exploratory case study that involved a small number of regular SI attendees; hence a conclusive argument cannot be made. However, I believe this issue of overreliance on support might apply to all students. Therefore, it requires further exploration.

In conclusion, it is hoped that this article will lead to discussion among academics in engineering faculties regarding teaching approaches and the influence they can have on student participation since learning is ultimately a shared responsibility between students and lecturers.

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