Engineering Students' Experiences of Social Learning Spaces in Chemistry Supplemental Instruction Sessions

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Abstract

Over the past three years, Supplemental Instruction (SI) has been introduced to the first year engineering and mainstream chemistry students at the University of KwaZulu-Natal as part of the 'Throughput in Engineering Sciences (TIES)' programme. SI is a student academic assistance programme providing regularly scheduled sessions for high risk courses. This programme aims to improve the throughput of the engineering and science students with the aid of support programmes for first year students designed on collaborative learning principles. Often, working in teams, students gain professional experiences that are designed to aid the transition to professional employment, building confidence, generic skills and capability in the discipline. This paper focuses on engineering students' experiences of the social learning spaces created in chemistry SI sessions. Data was collected using video-recordings of SI sessions, individual interviews and focus group interviews with students. Data was analysed using social constructivism as an analytical framework as it is the intention of this paper to understand students' experiences of the SI social learning spaces. The data reveals that engineering students experienced chemistry SI as discursive learning spaces offering opportunities for discussion, for reflection and meaning making, motivating students to take responsibility for their learning. It is argued therefore, that the social learning spaces created during the SI intervention session have the potential to develop independent lifelong learners in chemistry.

Keywords: social learning spaces, collaborative learning, chemistry Supplemental Instruction

Introduction

Learning spaces in universities are changing. Shifts in student mobility, pedagogy, curriculum management and technological tools are beginning to impact directly on the planning and development of campus learning spaces (Chang, Stern, Sondergaard & Hadgraft 2009). There has been a shift away from transmission models of learning to constructivist approaches which emphasise active, collaborative, peer and social learning (Lee 2006; Brown 2005). Reflecting this adoption of constructivist approaches to learning nationally and internationally, there is a shift away from the concentration on lecture and classroom spaces to now also include collaborative, informal and social learning spaces. In many cases, the rationale for these spaces extends to the enhancement of student agency and a shared construction of knowledge and learning contexts. The underlying aim of learning space innovation is to improve the student learning experience, and by association, transform student learning outcomes.

The Faculty of Science and Agriculture at the University of KwaZulu-Natal has recognised that students in their first year of study have particular learning needs as a result of their diverse backgrounds, previous learning experiences and their often under-developed learning skills. Supplemental Instruction (SI) has thus been introduced as a transitional support for first year engineering students. SI is a student academic assistance programme which applies strategies and aims at increasing academic performance and retention amongst students for high risk courses using collaborative learning principles. It is assumed that the students who participate in SI learning communities would become lifelong learners, able to think critically across disciplines and not needing to rely on being taught the information.

It would be interesting to establish whether the opportunities created for these social learning spaces allow students to work more collaboratively with peers during SI sessions. These questions are important to engineering education because engineering schools are supposedly preparing students, who as professional engineers, will be required to work in self directed ways through problem solving and collaborative team work.

It is assumed that the primary focus of SI sessions is aiding student assimilation and understanding of course content by thinking, reasoning, analysing and problem-solving (Phelps & Evans 2006). Martin and Arendale

(1993) have stated that SI leaders can assist students engage in thinking behaviour which facilitates connections between notes, textbooks and problem-solving. This is done in different ways which include students in SI sessions working collaboratively to understand the course concepts, brainstorming ideas, engaging in discussions of how the concepts relate to each other and reflection upon the task. According to McGuire (2006), these activities facilitate their greater conceptual understanding, and their success on problem-solving tasks and examinations increases substantially. This paper begins with a discussion of what constitutes a social learning space within a social constructivist paradigm as indicated by selected literature in which concepts are clarified. The methodology used in this study is then explored and the findings presented. The results from the focus group interviews and video recordings of SI sessions are then analysed to determine the ways in which the engineering students experience the discursive learning spaces created in development of chemistry concepts in chemistry SI.

Theoretical Framework

Internationally, as engineering schools grapple with how best to prepare effective engineers in the twenty-first century, there is a move from transmission models of learning and teaching towards constructivist models. At UKZN, groupwork skills are used on extensive projects such as design projects in mainstream teaching in the faculty of Engineering. In a number of universities worldwide, problem-based learning (PBL) and project-oriented and problem-based learning (POPBL) have also been introduced as part of the pedagogical tradition. SI, which was introduced at UKZN to supplement mainstream teaching as a student academic support programme, has constructivism as its theoretical foundation and bears many similarities to problem based learning as they function on the premise of collaborative learning. SI is based on three fundamental ideas viz. the idea of interaction as a prerequisite for learning, the idea of meaningful conditions for learning and the idea of questioning in a way that promotes the development of concepts (Mannikko-Barbutiu & Sjogrund 2004).

The notion of social constructivism has been given many interpretations. In one school of thought, the knowledge is constructed first on a social plane, and then internalised. This is strongly influenced by the work of Vygotsky (1978). Vygotsky's theories stress the fundamental role of social interaction in the development of cognition (Vygotsky 1978; Wertsch 1985), as he believed strongly that community plays a central role in the process of 'making meaning'. Vygotsky (1962) describes the zone of proximal development where learning takes place in discussions between students who have reached different levels in their individual learning and who can benefit from each other's learning experience and knowledge. This theory is central to SI where students come to solutions through common discussion. Authors who adhere to this view and considered knowing and learning in terms of culture and practice are Lave and Wenger (1991); Brown, Collins and Duguid (1989); Lave (1988) and Cobb (1994).

Wenger's (2000) conception of a 'community of practice' offers a possible model for a classroom that could facilitate learning through social interaction. Wenger described learning as taking place within collective activity in which individuals provide scaffolding for each other to acquire the skills and knowledge for participation. In a classroom modelled on a community of practice, students would not only interact with central participants, such as the teacher and in this study the SI leader. Students also interact with peripheral participants, such as other students at varying levels of skill. In such a view, learning involves not only developing new knowledge but also acquiring an identity associated with the group.

Situations in situated learning theory such as learning spaces are not necessarily physical places but constructs of the person's experience in the social environment. These situations are embedded in communities of practice that have a history, norms, tools and traditions of practice (Kolb & Kolb 2005). Social learning space refers to the myriad of physical and virtual resources which support student-centred, as well as interactive learning in formal and informal contexts (Oldenburg 1991 cited in Williamson & Nodder 2002). What kinds of spaces support the social dimensions of learning? Some answers have included providing spaces other than lecture halls and tutorial rooms and activities beyond lectures, such as dialogue and debate, small and medium group activities, group projects etc. (Chang, Stern, Sondergaard & Hadgraft 2009). There is a growing body of work relating to learning spaces across the education sector but it is beyond the scope of this paper to investigate evaluations of learning spaces but rather to explore the engineering students' experiences of the social learning spaces created during chemistry SI sessions.

A social perspective is concerned with ways of acting, reasoning and arguing that are normative in a classroom community (Cobb, Stephan, McClain & Gravemeijer 2001). Social scientific norms thus frame a student's reasoning as an act of participation. In SI, the dialogue is not made up of questions and answers but rather aims at rephrasing and redirecting the original questions. This allows the students to see the phenomenon from different angles and to develop concepts and achieve a more profound understanding of a phenomenon (Mannikko-Barbutiu & Sjogrund 2004).

Furthermore, (Johnson, Johnson & Smith 1991) indicate that social interaction leads to advanced cognitive development and promotes higher academic achievement than individual learning activities do. However, for collaborative learning groups to be successful, students are required to make a paradigm shift from the traditional model. This transition is not always an easy one, as many of our students have been conditioned since primary school to acquire knowledge from the teacher who is considered the key transmitter of knowledge. Data reveals that many of the first year engineering students have not made this paradigm shift as will be discussed later and are still fixated on the 'didactic model' of learning.

Methodology

A qualitative research methodology was used to understand the first year engineering students' experiences of the social learning created by the SI leaders. In this study, a sample of engineering students from UKZN was observed over a period of thirteen weeks (one semester). During this period fifteen SI sessions were observed in two different first year engineering chemistry modules. The qualitative research method employed in the study involved observations through video recording. The use of video-recordings helped to observe situations more than once.

Towards the end of the course, students were asked to attend focus group interviews on a voluntary basis to ascertain factors that influenced student learning through engagement. The main aim of this paper was to understand students' experiences of the social learning spaces created in chemistry SI sessions. Thus, to explore this aspect further, students were asked to describe the ways in which they felt the social learning spaces in chemistry SI sessions played an integral part in improvement of their understanding of chemistry concepts. Individual interviews were conducted with students with different academic performance in order to obtain a range of perspectives with respect to students' experiences of chemistry SI. This paper reflects the findings of the focus group and individual interviews and is compared and contrasted with the researcher's observations of the SI sessions to ascertain students' experiences of the SI social learning spaces. Students' names in the data analysis have been falsified to protect their identity.

SI Setting

An SI session is neither a lecture nor a lesson in the traditional sense of the word but rather a formal learning space where students discuss the subject matter on a voluntary basis and out of their own interest. The SI sessions integrate facilitative measures to encourage an atmosphere that emphasises that 'no question is a dumb question' (Webster & Hooper 1998), thereby encouraging students to ask the dreaded question 'why'. These SI sessions are usually held for 45 minutes twice a week. The learning spaces designated for SI sessions are flat rooms with approximately 5 round tables seating 10 students around it to enable communal arrangements. The limited seating per room was designed to facilitate small group discussions. This environment has been created to encourage a collaborative learning space during SI sessions.

SI leaders, usually third year or post-graduate students, are trained with respect to SI principles and facilitation techniques prior to commencement of SI sessions. The focus of the training is to introduce the basic ideas of SI to the participants and give them tools for their role as an SI leader. Besides the initial SI leader training, SI leaders receive regular training in facilitation skills, collaborative learning techniques and are mentored as well as supported throughout the semester. SI leaders use a variety of pedagogical techniques to facilitate student engagement and create an interactive collaborative learning environment through group and peer discussion, questioning techniques and student explanations.

SI sessions take the form of students either working in groups or pairs to discuss the problem followed by a team member responding to the solution of the problem through explanation of concepts and justification of claims. This is followed by a class discussion where SI leaders facilitate the discussion through the use of various questioning techniques such as the use of probing, redirecting and prompting questions.

Findings and Discussion

Students' Experiences of Social Engagement

It was found that social engagement did different things in the learning of chemistry such as motivated student learning, contributed to collaborative learning and lastly developed confidence through understanding.

Data from the focus group interviews and video recording revealed students' experiences of social engagement with respect to the following categories of description.

Inspiration through Support / Motivation

Learning chemistry during SI was regarded as a 'fun' endeavour which is revealed by the following student's description of his experience of engagement during SI sessions as being inspiring. He believed that his understanding in a sense increased because of the support he received from the SI leaders, as well as the fun he experienced in learning:

> *Engaging in SI sessions boosts our understanding of chemistry. The tutors are very supportive and your experience at SI is one not to forget. While learning we also have fun – so it makes us to want to learn chemistry because coming to SI is quite exciting.*

This student refers to the social aspects of learning by associating it with being fun, but only refers to the support received by tutors. However, he does not say what actually makes the learning fun. Zamo on the other hand explains why she thought her experiences of SI engagement were fun:

> *We get to work with many people and they have different ideas and so we also get to learn how other people think. So that's my definition of fun. Sometimes you can't do your things on your own – you know something about the question and someone else knows how to start then someone in the group assists you because they know and we carry on from there. We assist each other actually.*

This student associates 'fun' learning in chemistry SI as a social endeavour rather than an individual task that involves knowledge construction through various input, collaboration and support.

Students also reflected during the focus group interviews that motivation played a fundamental role in inspiring them to learn, which is represented by the following excerpts:

> *It is like when you like something you want to spend more time with it and keep on doing or practicing it.*

This student has another take on why she is motivated to study chemistry more than other subjects: she describes her predilection for the subject with respect to giving more time and practice to something you enjoy doing.

> *The way SI is carried out or the way SI is organised, when we come to SI we have a feeling of wanting to learn and as a result your mark is boosted because of the knowledge gained during the SI session.*

This student is motivated by different learning styles offered by the SI sessions which in my opinion, probably refer to collaborative learning styles. He further recognises that motivation to learn is linked to the learning that takes place.

Joe in contrast, is motivated by the solutions to problems he receives at SI where he is able to reflect on his understanding of concepts:

> *… it wakes up your mind and motivates you after you have been failing – a you realise where you went wrong and you get some solutions.*

Other students further suggested that they are motivated to take responsibility for their learning by attending SI sessions because they are aware of the vast content that is covered in class and are either overwhelmed by amount of work to be covered or feel that they can only achieve the learning with support and guidance that SI offers.

The discussion above reveals that learning in chemistry SI is regarded as a 'fun' learning experience through collaborative learning engagement, exposure to a diversity of learning ideas and the support that is received in learning. It is evident that motivation also plays a significant role in chemistry SI by encouraging engagement with difficult stoichiometry concepts, thereby increasing students' confidence through collaboration and support.

Collaboration

Students' collaborative learning engagement were described in several ways which is discussed as follows, firstly students recognised that learning is a social endeavor which developed a better understanding of concepts through exposure to different points of view which is depicted by

> *… while I was working in a group I found that what I knew, was not better than what others knew so it is better to work in a group.*

This point is further emphasised by the following excerpt:

> *I feel that one of the good experiences are that you get to work in groups and with different people which really clarifies your understanding of chemistry concepts because people might really have different views, methods or ways of working out stuff and …so in that way I think it clarifies chemistry concepts.*

This student seems to value group work or collaborative learning as she believes that the variety of input received during group discussions has improved her understanding of chemistry concepts. These sentiments are further emphasised by Mbonga who expresses that the '*explanations received during collaborative learning have also been good*'.

Group discussions also seem to serve as a means of revision as is indicated by this student who remarks

> *If you talk to each other you find out that, oh, you forgot this, and tend to remember things you forgot*.

Working in collaborative groups during SI sessions appears to expose students to different ways of answering a question; this was described as motivation for learning as discussed earlier in this chapter. The following excerpt describes Amanda's experiences of collaborative engagement:

> *You find that when you work on your own you sort of use that same methods but when you come to SI like you find other methods used by people, which are much easier than the one you were using, in that way you benefit.*

This student values collaborative learning in gaining exposure to different methods used in problem solving, which she views as beneficial in clarifying her understanding of concepts.

The discussion above indicates that collaborative learning has many roles which are represented by developing a better understanding of concepts through exposure to different points of view; explanations have been useful and also serve as a means of revision of concepts. It can therefore be concluded that collaborative engagement allows students an opportunity to learn from each other as suggested by Akash in his individual interview: '*we definitely learn from other people*'.

The following students describe how group or paired problem solving increased their confidence in attempting to answer questions during class discussions in chemistry SI sessions:

> *'If you discuss the answer in a pair you feel sure of your answer*'.
> *'Discussing in pairs first helps in answering in front of the class'.*
> '*If you know each other you feel more comfortable and it is much easier to talk and go up to the board'.*

These students ascribe their increase in confidence to the collaborative learning styles used in SI sessions which encouraged discussion and participation and developed a sense of familiarity with other students in the class.

This point is highlighted by Thuli who claims '*I find it easier now to approach people if I have a problem because I know that everyone here wants to learn'*. This student expresses that she now finds it easier to ask questions with respect to developing an understanding because she has come to the realisation that everyone at SI is there to learn and does not feel intimidated by asking questions.

Akash mentions in his individual interview that '*the effort that we put into group discussions makes us feel good even if we come up with solutions that sometimes might be wrong*'. This comment suggests that collaborative engagement allows students an opportunity to construct a shared understanding of concepts which gives students a sense of confidence, rather than having no idea on how to attempt the problem.

Mbonga on the other hand revealed that he feels that collaborative learning is not always good for him. In some instances, when he cannot contribute towards the right answer, he becomes frustrated and has negative feelings of group work, which is depicted by the following remarks:

> *Group work is not always good – because sometimes if you don't have a clue of what is happening – you end up asking and asking you feel a bit silly and like the silly person who doesn't know anything in that group.*

This student shows a lack of understanding of meta-cognitive skills required in learning. He is more fixated on knowing the right answer rather than developing an understanding contributing to knowledge construction through discussion and support.

It is evident from the excerpts above that discussion and collaboration amongst peers seems to develop a sense of confidence which motivates the engineering students' ability to learn from each other. There are, however, other opinions that collaboration is not always successful but rather, is seen to develop negative emotions among students who feel that they have nothing to contribute to the discussion.

Opportunities for Social Engagement

Students in this study believed that the opportunities created during SI sessions for social engagement provided feedback that improved their understanding as well as their confidence in sharing answers. Students described the different ways in which such opportunities were created during the SI sessions for social engagement among students and the SI Leader. Commenting on an SI Leader, several students observe the following:

> *'She asks us to explain in our own words and usually uses the feedback thing where she asks what do you understand by that question?'*
> '*The SI leader asks another group to help when no one knows in our group', or*
> *'She also asks what do you understand by the question …then you realise what is actually being asked';* and
> *'She asks what is given and why it is given, or she asks us to refer to our notes'.*

These questioning techniques are portrayed as opportunities created for engagement during SI sessions in developing a better understanding of chemistry concepts.

This reflects the student's understanding that the process of learning is more important than the product. What also comes through is the fact that this student valued the feedback or support received from other students and the SI leaders. On the other hand it would seem that some students still focus on the product of the exercise, which is evident from the individual interview with Nivashni who states that she will only go up to the board to explain a concept if she is confident that she has the correct answer:

> *I would go up to the board but I mean it depends how confident I am about my answer.*

This statement indicates that students' confidence is influenced by their understanding of chemistry concepts. She goes on to explain:

> *I do feel comfortable and safe and stuff there, but if I know for sure my answer is wrong I wouldn't .… I'd let someone else do it and then I can correct my mistakes and know where I went wrong.*

This statement indicates that the environment encourages varied degrees of confidence with respect to learning engagement, and it influences peer learning when students lack confidence in their understanding of concepts.

Zamo, on the other hand, reveals in her individual interview that '*if you explaining to other people you feel like I'm superior, I know the stuff and you feel more confident*'. This comment further supports the finding that the SI environment encourages different levels of confidence with respect to learning engagement, which is dependent on students' understanding of chemistry concepts.

Students have also indicated that collaborative learning techniques offered in chemistry SI have assisted in increasing their confidence in contributing to explanation of concepts in their own words; this is depicted by the excerpt below:

> *She'll give us a specific problem …. we'd all answer it and we compare our answers and we see that it's right and then you get confident knowing that someone else also has the same answer as you so I mean its' confidence that maybe you answer is right but even if it isn't you are corrected there and at least you learn from your mistakes.*

However, only when prompted with respect to the different types of social engagements opportunities experienced in the SI sessions do students actually come up with the examples of how they engage during SI sessions. This in a sense reveals that not all students are aware of how they learn and value the support and feedback from the SI leader more than their attempts to develop an understanding of concepts.

These different opportunities for social engagement are valued by students which are depicted by the following excerpt:

> *… in lectures we do not necessarily have the time to go over the notes but when you go over the notes with another person I find that you understand better.*

This student describes how collaborative discussion of lecture notes improves his understanding of chemistry concepts. Students also illustrate that collaborative learning techniques such as paired problem solving also create opportunities for engagement which is depicted in:

> *She also pairs you and when paired with different people you become more comfortable around different people.*

This student further explains that these collaborative techniques encouraged student engagement by creating a more relaxed environment where students were familiar with each other and this is believed to break barriers to engagement in the SI sessions.

Some of the students displayed an understanding of the different meta-cognitive skills required in developing an understanding of a concept which is represented as follows:

> … *She allows you to speak in groups but she does not leave you hanging and she verifies your answers'.*
> *'She gives one person an opportunity to explain the way they understand it'.*
> *'Everyone is involved in the activity it's like not you alone or you and your partner are not the only one involved in the discussion'.*

Students therefore indicated that opportunities for social engagement were created by the SI leader who developed an understanding of chemistry concepts through feedback (*verifies your answers*), explanation (*gives students an opportunity to explain*), and the use of collaborative learning techniques (*everyone is involved in the activity*). Social engagement was experienced as a fun way of learning, inspired learning through peer motivation and support, it created collaborative learning opportunity, developed confidence through understanding and created opportunities for feedback.

A social constructivist perspective reveals that deep understanding is dependent not only on exploring values and having social interaction, but on engaging all other aspects of the person as well, including attitudes, emotions, aesthetic experience and behaviour (Leithwood, McAdie, Bascia & Rodrigue 2006). This perspective is consistent with the engineering students' views on their experiences of how they engage during chemistry SI sessions.

Socio-constructivist theories confirm the importance of community and interactive forces to motivation, which in turn link effective teaching with modes of delivery that promote engagement and discussion (Cannon 1988), particularly in ways that encourage active and equal participation. Motivating approaches to pedagogy can also be considered important from the perspective of responding to the diversity of students' learning styles and preferences. This study highlights the collaborative learning activities offered to the engineering students in chemistry SI that have the potential to assist in promoting deeper levels of knowledge generation (Felder 2003), as well as develop initiatives and higher order thinking (McLoughlin 2000).

The results above reveal three broad themes with respect to student experiences of the SI social learning spaces, viz. through motivation to learn, collaboration among peers and opportunities for social engagement.

Conclusion

Students regarded their experiences of the social learning spaces created in the chemistry SI sessions as inspiring because of the support they received from SI leaders and peers. They developed a better understanding of concepts through exposure to different points of view and different pedagogical activities offered. The findings reflect that the different pedagogical and learning techniques offered in the SI social learning spaces accommodated for the diversity of students' learning needs, encouraging students to take responsibility for their learning through feedback, motivation and support. Social spaces served for mini revision of concepts, explanations and discussions that improved understanding of concepts and collaboration amongst peers which increased students' confidence in answering questions.

The findings from this study show that SI social learning spaces create opportunities for learning engagement that differ from lectures in many ways, particularly as they relate to:

- offering more opportunities for practice and reflection;
- access to a variety of questions;

- access to support and immediate feedback;
- opportunities for collaboration;
- students taking responsibility for learning; and
- motivation to learn.

Students commented that student focused learning, which involved peer teaching and learning, encouraged them to:

- develop thinking, reasoning and social skills which enabled them to engage with the problem solving activities more effectively;
- develop confidence with respect to making appropriate choices in terms of chemistry concepts; and
- explore, question and research other alternates as a fundamental component of their learning.

It is evident from these responses that students who engaged in these social learning spaces developed a better understanding of concepts through collaboration. It is therefore argued that the social learning spaces created during the SI intervention session have the potential to develop independent lifelong learners in chemistry.

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