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Exploring the possibility of introducing Supplemental Instruction at secondary school level

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Globally, mathematics and science pass rates at school level have been a much discussed and researched issue. Teachers are tasked with the responsibility of alleviating learners' challenges associated with the learning of mathematics and science. Thus, teachers are pursuing innovative techniques for improving the understanding of and increasing the pass rates in mathematics and science. Academics in higher education have recognised that first year students experience difficulty with high-risk courses such as mathematics and science. One successful innovative strategy used at university level is Supplemental Instruction (SI). This is a peer support programme, which targets high-risk courses, and is aimed at developing subject-specific learning skills to foster independent learners, who will take responsibility for their own learning. This article explores the SI context at university level, with the aim of adapting this type of support programme at secondary school level. Data was collected via a questionnaire administered to selected academics, interviews with academics, as well as interviews with university students who have participated in SI sessions at university level. An analysis of the data suggests that schools may be able to adapt the SI model with the aim of assisting learners to develop key study skills to improve understanding in mathematics and science. This improved understanding of content could lead to an improvement in mathematics and science pass rates at secondary school level.

Keywords: mathematics; science; SI

Introduction

How well learners in a country perform in mathematics and science is a predictor of economic growth, as it points to the quality of the human capital pool (Aguele & Usman, 2007; Raghunathan, 2003; Siyepu, 2013; Vorderman, Porkess, Budd, Dunne & Rahman-Hart, 2011). Therefore, knowledge of mathematics and science is important for the social and economic progress of South African society (Reddy, 2005). By this I mean that, many careers that could assist with the acquisition of social and economic advancement, for example careers within the field of engineering, applied sciences, accounting, architecture, medicine and law, require a good pass in mathematics as a requirement for entry into these careers (Siyepu, 2013). Much research has been conducted (Adler, 2013; Bansilal & Naidoo, 2012; Naidoo, 2012, 2013; Reddy, 2006; Sanders, 2002; Setati, 2006; Setati & Adler, 2001) focusing on South African learners' skills in mathematics and science. The results of these studies indicate that learners exhibit limited skills, or that learners lack the necessary skills required to produce promising mathematics and science results. Moreover, the majority of schools in South Africa face many challenges in improving access, participation and outcomes in mathematics and science, due to vast backlogs with respect to the provision of basic infrastructure, learning materials and qualified teachers (Reddy, 2005).

In 2011, learner performance in the Trends in International Mathematics and Science Study (TIMSS) ranked South Africa at the bottom end of the scale, viz. 44th out of 45 countries, with a country average significantly lower than the TIMSS low performance benchmark. The TIMSS report has been published every four years since 1995 by the International Association for the Evaluation of Educational Achievement (IEA). The TIMSS provides an opportunity to assess and benchmark South African mathematics and science performance on an international level. The Human Sciences Research Council (HSRC) conducted the research for the TIMSS on behalf of the IEA in South Africa. Approximately 12,000 Grade Nine learners participated from 256 public schools, and 27 independent schools, in 2011.

If learners are taught how to take responsibility for their own learning and development of intrinsic motivation from an early age, this could have a significant impact on the overall improvement in mathematics and science results. In this way, more learners will be adequately prepared to enter careers utilising mathematics and science. It is therefore suggested that the SI model be introduced at secondary school level in an attempt to assist learners in developing subject-specific and learning skills in the hope of fostering independent learners, who feel equipped and confident in their ability to successfully complete traditionally challenging course material. Supplemental Instruction learning principles may also be used to bridge the gap between secondary school and higher education institutions, by engaging learners in meta-cognitive learning with the aim of making science and mathematics more accessible at university level. The study aimed to answer the following key research question: what is the possibility of introducing a SI model at secondary school level?

Data was collected in order to establish whether SI principles could be adapted within the SI model for secondary school teaching and learning. This article begins with a discussion of the SI context at university level. This discussion is followed by a description of the methodology used in this study. The results and findings are then analysed, with the aim of exploring the possibility of introducing SI at secondary schools in South Africa. This exploration is encouraged; with the intention of improving the current mathematics and science pass rates, in the hope of thereby adequately preparing students to enter careers that utilise mathematics and science (Ning & Downing, 2010).

The Supplemental Instruction Context at University Level

The SI model, which is an academic support programme that originated in 1973 at the University of Missouri Kansas City (United States of America), is a peer learning support programme, based on collaborative learning principles. Supplemental Instruction is based on the principles of peer learning, encouraging contact between students and faculty, developing reciprocity, co-operation and collaboration amongst students, encouraging active learning, promoting the development of study skills, providing prompt feedback, as well as developing metacognition. Peer learning is an established method for promoting student learning (Ning & Downing, 2010) and is used in Higher Education globally (Medina, 2003). Supplemental Instruction is a voluntary support programme and focuses on assistance in building peer-to-peer interaction, motivation and self-efficacy amongst students. It focuses on providing additional support, especially on courses that are considered high-risk.

Supplemental Instruction was introduced as a support programme for the first-year engineering and science students at the participating university in 2008. The SI sessions at university level provide students with opportunities for engagement with course content through group and paired discussions. In addition, SI allows for the explanation and discussion of key concepts and it encompasses the use of various questioning techniques whereby immediate feedback is provided to students.

This article reports on research that was conducted to explore whether or not SI principles employed at university level could be adapted for learners at secondary school. The aim of adapting SI at secondary school level is to assist learners with the development of key study skills to improve understanding in mathematics and science. Supplemental Instruction provides regularly scheduled peer facilitated sessions, where students have the opportunity to assimilate and understand course content by means of thinking, reasoning, analysing and problem-solving (Phelps & Evans, 2006). Arendale (1993) state that the SI leader's role is to assist students in engaging in the type of thinking behaviour that facilitates connections between notes, textbooks and problem solving. This is done in different ways, where students within SI sessions work collaboratively and participate actively to understand the course concepts, to brainstorm ideas, to engage in discussions, and to analyse and reflect upon key concepts being discussed. According to McGuire (2006), these activities facilitate students' conceptual understanding and promote success in problem-solving tasks. These studies have shown a substantial improvement in examination results of students who participated in SI sessions (Arendale, 1993; Phelps & Evans, 2006).

Within the SI context, there are different role players: an SI leader who facilitates the SI sessions, the SI supervisor, who monitors and mentors the SI leader, the faculty partners for the high-risk courses who advise the SI leaders on what sections of the course have been completed, as well as the students who participate actively within the SI sessions. Supplemental Instruction leaders are usually students, who have already completed and passed the courses for which they will be facilitating. The leaders are selected based on academic merit (many programmes require a B symbol or higher, and steady academic progression in general) in the courses for which they would be assisting students. Supplemental Instruction supervisors train SI leaders with respect to SI principles and facilitation techniques prior to the commencement of the SI sessions. This training is provided by an SI supervisor during a kick off training session, which varies from programme to programme. The focus of the initial training is to introduce the basic principles and techniques of SI to the SI leaders, and to provide them with instructional tools. In addition, the training assists the SI leader in becoming acquainted with logistics and administrative responsibilities while preparing both to meet the faculty partners, as well as to introduce the SI model to students.

Besides the initial SI leader training, SI leaders receive regular ongoing training focusing on academic strategies; leadership development; team-building; relationship-building techniques; learning theory, facilitation skills and collaborative learning techniques. Supplemental Instruction leaders are mentored and supported throughout the semester by the SI supervisor. The Supplemental Instruction supervisor is trained by the national Center for SI, and is well acquainted with SI methodology. The SI supervisor serves as a mediator of course content in collaboration with the lecturer of the course. The SI supervisor provides mentoring and support to SI leaders through the observation of SI sessions. Feedback is provided to SI leaders on a regular basis. All SI leaders are remunerated for their efforts in planning, facilitating and administering of the SI sessions.

At university level, students are not compelled to attend any of the SI sessions; they may attend if they require the assistance provided by the SI facilitators and other SI participants. Therefore the voluntary nature of SI adopted at university level provides students with an opportunity to take responsibility for their own learning. With the support of the SI leader and peers, students are encouraged to develop problem-solving skills within a collaborative environment. Hence, the SI leader, through facilitation, interaction, open discussion, scaffolding and explanation, promotes learning in a socially non-threatening environment where students can 'safely' make mistakes (Fayowski & MacMillan, 2008).

The Teaching and Learning of Mathematics and Science at Schools in South Africa

To perform fully in democratic processes and to be unrestricted in career choice and advancement within society, learners must be able to understand and apply complex and abstract mathematics and science ideas. Mathematics teachers are constantly looking for innovative and stimulating teaching strategies to encourage and sustain learners' attention in mathematics classrooms, with the aim of improving mathematics pass rates (Naidoo, 2012). One such innovative strategy teachers could implement at secondary school level is the SI model.

Similarly, the teaching and learning of science, which is viewed as important for the social and economic development of South Africa (Reddy, 2005), may also benefit from the adaptation of the SI model at secondary school level. Supplemental Instruction has been found to be methodologically successful as a support programme for first-year students in higher education in South Africa (McCarthy, Smuts & Cosser, 1997; Paideya, 2011; Pocock, 2012; Zulu, 2003), therefore it is suggested that a SI model could be adapted for the secondary school milieu.

By adapting the SI model at secondary school level, learners will have more opportunities to engage and interact with their peers in discussion groups focusing on content, procedures and problem-solving. This may be beneficial in improving mathematics and science pass rates in South African schools that do not have well-trained science and mathematics teachers, resources or laboratories (Modisaotsile, 2012). In addition, SI sessions at secondary school may scaffold the learning of abstract concepts and provide learners with opportunities for further engagement with complex concepts outside the classroom. This may be beneficial to the mathematics learners, as they ought to be exposed to various approaches for solving a variety of equations, for example, linear, quadratic, and cubic equations in mathematics (Maharaj, 2008).

Although the SI model is traditionally aimed at supporting students, if implemented at secondary school level, teachers would also benefit from having additional support in the form of SI leaders, who would be able to assist learners in consolidating what was taught during the lessons. While it is acknowledged that SI alone may not solve all the problems that teachers and learners face at secondary school level, the goal of the SI model would be to improve learners' study skills, deepen their understanding of mathematics and science, and adequately prepare them to enter careers in mathematics and science.

Theoretical Framing

This study was framed within the ambit of social constructivism. Social constructivism focuses on learning as it takes place through social interaction and mediation within meaningful contexts (Kim, 2001). Meaningful contexts are created within active learning milieus, within which the teacher and students communicate effectively, in order to encourage social interaction to advance peer collaboration (Powell & Kalina, 2009). Consequently, teachers need to create learning milieus, where opportunities for communication, conversation and scaffolding are provided to assist learners in constructing the knowledge they need to acquire. Mathematics and science conversation can lead to a deeper understanding of the language of mathematics or science. Through communication, ideas are reflected upon, refined and remembered. As learners learn to speak mathematical or scientific language, they transform their thinking of the concepts. The creation of mathematical or scientific language is thus improved by making meaning through processes of social interaction and language (Vygotsky, 1978).

Supplemental Instruction leaders at university level provide scaffolding, as students learn to think within the context of the course. They provide direction and suggestions and clarify concepts and theories, thus reflecting on the meaning-making process. Scaffolding is most effective if it involves tasks within the learners' zone of proximal development (ZPD) (Naidoo, 2012). The ZPD refers to the difference between what a learner can do without assistance from a peer or teacher, and what a learner can do with this assistance (Siyepu, 2013). Vygotsky's (1978) view is that through the use of scaffolding, individuals may acquire an in-depth understanding of concepts. Scaffolding in a classroom may be achieved through modelling, feedback and dialogue. Through training and support, the SI leader develops the skills necessary to model effective learning and study strategies in the discipline. The SI leader is thus able to provide constructive feedback to students and to support students' interactions within the SI sessions. This model could be adapted at secondary school level, where SI leaders are supported by teachers, or by externally funded SI supervisors, in developing learners' mathematics and science conceptual knowledge.

By providing students with instruction that links new knowledge to prior experiences, SI may assist learners who are concrete thinkers, to start thinking on abstract level. University students who reason at a concrete level may experience difficulty processing new information and linking it with prior knowledge they possess. This additional layer of support is critical for concrete thinkers, as generally, these opportunities are not otherwise available in the high-risk courses such as mathematics and science, which many SI programmes target. Supplemental Instruction also seeks to enhance students' meta-cognitive abilities.

Metacognition refers to "one's knowledge of one's own cognitive processes" (Flavell, 1976:232). If a student is cognitively aware of how they are studying, then that student may know what problem-solving plans and techniques to use, and how to think about the content in order to grasps the abstract concepts. Most students are not 'naturally' metacognitively aware, and it is found that this skill only develops much later in students' lives (Bransford, Brown & Cocking, 2000). Therefore, a student may either fail or succeed at an examination and have no idea why. Supplemental Instruction can assist, since one component of SI requires the SI leaders to incorporate modelling of study skills relevant to the content. Supplemental Instruction leaders attempt to engage students in actively thinking about what mental processes they used when they were successful, and what they used when they were unsuccessful.

Methodology

A qualitative study was carried out framed within an interpretive paradigm. Ethical clearance was obtained from the participating university's Research Office. Each participant was provided with an informed consent form, which informed participants of the scope of the study as well as of their right to withdraw. The participants were also made aware of their role in the study. Further permission was sought from the participants for the interviews to be audio-recorded.

Twelve academics working at a university in KwaZulu-Natal (KZN), South Africa, were invited to participate in the study. Twenty students who had attended SI sessions were also invited to participate in the study. Seven academics and 15 students responded positively to the invitation. A pilot study was conducted with a small sample of the participants (three academics and five students). Data was collected via a questionnaire for the academics and semi-structured interview schedules. The purpose of the pilot study was to ensure that the data collection instruments were valid and reliable.

For the main study, the remaining four academics were asked to complete the revised questionnaire, and they were subsequently interviewed. The purpose of the questionnaire was to gain additional information regarding the academics' teaching experience within Higher Education, their knowledge of SI, and whether or not the courses they taught had the support of SI leaders. The academics were interviewed based on their responses on the questionnaire. The interviews assisted in probing and clarifying their responses to the questionnaire. Furthermore, the interviews with the academics also aimed at exploring the academics' views as to whether or not SI could be adapted at secondary schools with the aim of improving learners' study skills, deepening their understanding of mathematics and science, and adequately preparing learners to enter careers utilising mathematics and science.

Subsequently, 10 students who attended SI sessions at the participating university were interviewed. The focus of these interviews centred on the students' views on the benefits or limitations of SI with respect to improving their study skills, deepening their understanding of the content required for the high-risk courses, promoting active learning, and encouraging peer collaboration. To ensure the internal validity of the study, all interviews were recorded and transcribed. Each recording was played several times to ensure that there were no mistaken transcriptions. Furthermore, the researchers ensured that the academics and students understood the concepts under focus.

With respect to the profile of the academics, two of the participants were academics from the Mathematics Department (A1 and A3[i]); the other two academics were from the Science and Engineering Departments, respectively (A2) and (A4). Additionally, the four participating academics were former mathematics and science educators at secondary school level, and also had the experience of being SI supervisors.

The academics were chosen as important sources of data, due to their knowledge of the current state of schools in South Africa, both provincially and nationally, where all four were trained SI Supervisors. These academics were SI supervisors who subsequently trained SI leaders and monitored SI programmes within their respective disciplines. They were therefore deemed to have sound knowledge of the dynamics of secondary schools, and were known to interact with teachers from the diverse categories (in terms of infrastructure and resources) of schools in KZN. The participating students had taken part in SI sessions for mathematics and science at the university. It was of value to the study to establish their perspective on adapting the SI programme in secondary schools. These interviews with the students provided important data regarding some of the benefits and limitations such an intervention would reveal.

Data Analysis

All data collected was analysed qualitatively. Memos were written by the researchers during the interviews and the data collection process. These memos were reflected on during the data analysis process, and constituted the first stage of data analysis. They further assisted with the coding process, where the responses to each questionnaire were coded. The coding assisted with stage three of the data analysis process, developing categories. All interviews were transcribed and categories were developed. Finally the categories assisted in developing and constructing themes for this study. Three major themes emerged for this article: understanding the SI model and its implications for change; the creation of a structure for learner support at secondary schools; and the adaptation of the SI model for secondary schools.

Findings and Discussion

The questionnaires were analysed in order to develop semi-structured interview schedules for the participating academics. Transcripts from the interviews were analysed to determine the views of both the academics and students with respect to the implementation of SI at secondary schools. Three themes evolved from the data as follows:

- understanding the Supplemental Instruction model and its implications for change;
- creation of a structure for learner support at secondary schools; and
- the adaptation of the SI model for secondary schools.

These themes will now be discussed in more detail.

Understanding the Supplemental Instruction Model and its Implications for Change

As would have been expected, the academics displayed a good understanding of the SI model indicating that:

> A1: "*Supplemental Instruction involves active participation of students in small collaborative groups…*"
>
> A2: "*…it is a peer-facilitated learning experience for all students in high-risk modules…*"

The participants[ii] further suggested that SI:

> A1: "*…offers conceptual clarity to students based on students' needs…*"
>
> A2: "*…involved active participation with a view to understanding module content better…*"
>
> A3: "*…involved collaborative/active learning through discussion, reflection, brain storming of ideas and a variation of questioning techniques…*"
>
> A4: "*…involved training students to take responsibility for their learning.*"
>
> S8[iii]: "*…helps because you* [sic] *work in groups and you* [sic] *learn from your peer's solutions and their way of working problems as well…*"

These findings correlate with social constructivism, whereby students are noted to actively engage with members of the learning milieu to socially construct meaning. Based on the excerpts taken from the interview transcripts, this active engagement involved discussion, brain storming of ideas, working collaboratively within groups and engaging with a variety of questioning techniques.

It was important in this study to determine the participants' understanding of the SI model, in order to further understand their views of whether SI could be adapted for secondary schools. The participants were purposively chosen to inform this research since they had a good understanding of Supplemental Instruction principles and practice. In addition, the academics were former secondary school science and mathematics teachers and would therefore be able to provide responses from this perspective as well. Due to their experience and understanding of the SI programme, both the academics and students provided valuable data regarding the benefits and limitations of adapting Supplemental Instruction at secondary school level.

Creation of a Structure for Student Support at Secondary Schools

When participants were asked their opinions of peer learning models for schools, the following responses were received:

> A1: "*…it provides help to students in need…*"
>
> A2: "*…well thought out models which take into consideration managing group work dynamics have a place at schools…*"
>
> S9: "*…at school, it would have been a benefit to us, we would not have been alone we would have others with similar problems and then the leader would help us work through these problems…*"

When further probed, one academic (A2) mentioned that secondary school learners may lack the necessary group work skills to take on the responsibility of collaborative learning. In addition, it was suggested that learners could also be confronted with other challenges, such as peer pressure, which might work against constructive engagement with mathematics or science concepts. It was implied that presently, the school ethos suggests that only the teacher is knowledgeable, and that this creates a sense of mistrust with peers, which could result in ineffective learning. On this basis, it was suggested that "*well thought out models*" [A2] which took into consideration the above factors have a place at schools.

One of the participants (A4) commented that "*schools foster a competitive spirit*" through academic grading. This suggests the main focus to be examinations and products; rather than developing the processes of learning and developing lifelong learners. It was therefore suggested that the SI programme could enhance the development of learner's meta-cognitive learning skills at school level, better preparing them for tertiary education.

Other participants made the following suggestions regarding peer learning models, where it was noted that it: "…*resonate*[s] *with the curriculum policy for schools*…" and such a model "*underpins the theoretical basis for cooperative learning*…" (A3). This argument was supported by participants who indicated that:

A3: "…*peer learning has a place in mathematics education…learners learn from each other through code-switching, to explaining in their own way*…"
S2: "…*you learn more when you try to teach something to someone*…"
S3: "…*group work boosts your confidence and if you discuss the answer in pairs you feel more sure of your answer…group work helps*…"
S10: "…*especially when we do not understand a certain thing, if someone helps us understand in our language then we would understand better. We should have done this at school, it would make life so easy…so many things that we did in school are being tested in university, like catalyst, reactions, coefficients*…" [sic].

These transcript excerpts are in harmony with the theory of social constructivism, whereby group work, collaboration among students, peer teaching and communication are valued and encouraged. The participants continued by saying:

A3: "…*students seem to have a common way of understanding each other – 'in sync' – no better way to learn…they begin to accept it as a human activity that they all engage in* [sic]…"
S2: "…*I'll be honest,* [sic] *everyone doesn't contribute* […] *maybe they are just shy or they just don't want to try… but we try and get everyone involved by asking different people to look for information in the textbook or the lecture notes*…"
S4: "…*we all answer* [the problem] *on our own 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 …* [sic] *I recall when it came to balancing equations I was not always very confident with my answer, as I often confused the subscripts and the coefficients of the chemical formula, but working in groups allowed me to develop the skill of balancing chemical equations*…"[iv]
S7: "…*language is a problem for me; I think the discussions in the SI sessions help me understand what is being taught*… ."

These comments suggest that peer learning models could work well at schools, and more particularly, with second language learners. This would be highly beneficial in the teaching and learning of mathematics, since research (Maharaj, 2008) indicates that learners encounter many difficulties when they are exposed to word problems.

However, one participant indicated that: "…*peer learning models may work at school level but it is the logistics of initiating and sustaining such models that may cause problems*…" (A1).

This remark indicates that the participant agreed that peer learning models have a place at school level, through proper implementation and support of such models.

The adaptation of the Supplemental Instruction Model for Secondary Schools

The majority of the participants believed that SI could be adapted at secondary schools. This is evident where the participants comment that the success of the SI programme in schools depends on teachers' awareness of the challenges, support and guidance learners require to succeed at school:

A4: "…*it is possible, provided assessors/facilitators have a deep understanding of students' potential for success and their challenges…an understanding of the dynamics of schools, as well as the visions of all stakeholders for education, is vital*…"
S5: "…*you feel like for the next SI I need to do more limiting reagent questions and I have to be prepared and you start preparing by doing other examples so you know what you don't understand and you can get help in SI…the leaders are always prepared and know how to help*…"

Two of the participants justified their comments that peer learning programmes are possible at school by indicating that they were aware of high schools in Durban that used similar models for tutoring learners. Within SI sessions, tutoring is mutually beneficial to both the students and SI leaders. While the students gain assistance with content, study skills and collaborating with peers, the SI leaders develop academic and leadership skills. Based on the findings it was evident that the symbiotic nature of the SI model is also in line with the theory of social constructivism. This theory is based on the tenets of collaboration, cooperation and active participation of all members that engage within the learning milieu.

A2: "…[the] *school has student leaders tutoring the younger learners in mathematics*…"
A3: "…*the school has used learners in upper grades to tutor mathematics learners in lower grade*[s]…"

In an attempt to determine the effectiveness of such peer learning programmes at secondary school level, it would be interesting to assess the similarities and differences of these peer learning programmes in relation to SI principles. When asked which aspects of the SI underpinnings would work at secondary school level, the following responses were received:

A1: "…*Supplemental Instruction can assist learners to link new knowledge to prior existing knowledge*…"
A2: "…*learning from peers has a place at school*…"
A3: "…*the active discussion amongst learners about difficult problems and concepts*…"
A4: *"…the teaching of good study habits and study skills…"*
A4: "…*active learning principles, discussion sessions, quizzes (with great support from the teacher), student-driven agendas, and group activities would definitely work at school...*"
S1: "*...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…"

The majority of the participants agreed that the SI principles of active learning, group and peer discussions, probing and students taking responsibility for their learning have potential in developing learners at secondary school level. These principles are in line with the principles of social constructivism. This is evident in the excerpts that follow:

S2: "…*I am more confident that my answers are correct or I am close to the correct answer, which is a confidence booster* [sic] … *and I am more confident to explain my method of answering the question to my group members who let me know where I am going wrong*… ."

S6: "…*at SI there's a whole lot of* [sic] *other people there so they come in with different questions and different angles of thinking, and for example, if* […] *you feel that there's a set method in which to calculate, some other person might have a completely easier* [sic] *and different way* [which] *saves you time* … [it is most likely that their] *method is less time consuming. A typical example was writing mole ratios or showing stoichiometric relationships between reactants and products … I must admit I learnt an easier method of doing this in SI*…"[v]

S10: "…*it would have been better if we did these sessions in school, we would have done so much better in school*… ."

The participants agreed that there could be time and management constraints on the part of SI leaders, as reflected in the comments below:

A2: "…*managing disruptive learners could pose a problem*…"

A4: "…*Supplemental Instruction leaders finding time to attend other lessons besides their own, prepare, maintain registers*…"

In support of the above comments, considering learners' level of maturity with respect to managing group dynamics, disruptive learners and facilitating the SI session, this matter might become problematic with younger leaders. Also, since school timetabling does not give learners much free time with the exception of lunch and a tea break, this would not allow the senior learners to attend the junior classes to become familiar with the content being delivered for the week. Preparing SI session content would therefore need much guidance and support from the teachers or the SI supervisor in charge.

A project was carried out in Sweden (Mannikko-Barbutiu & Sjogrund, 2004), which sought to overcome similar challenges. The researchers mention the use of university students or a combination of both university students and high school learners as SI leaders in schools. Although this research was carried out internationally, the context is similar to the South African context in many ways. It is therefore encouraging to know that this study could be mirrored in South Africa, thus fostering the possibility of adapting the SI model at secondary schools in South Africa. The aim of this implementation would be to improve learners' study skills, to deepen their understanding of mathematics and science, and to adequately prepare them to enter careers utilising mathematics and science.

Since the remuneration of learners for their efforts would be virtually impossible considering the lack of financial support experienced by most schools, and more especially in the lower socio-economic groupings, learners acting as SI leaders in schools would need to participate on a voluntary basis, or alternatively, they could be given academic credit or a leadership certificate for their participation. The SI leader positions could be marketed based on the benefits to the SI leader with respect to improved leadership qualities, conceptual knowledge and meta-cognitive skills (Couchman, 2009).

Conclusion and Recommendations

Reddy (2005) maintained that to improve a country's mathematics and science results, it would be important to improve the quality of education at school level. One way of improving the quality of education at school level would be to introduce SI principles in order to complement mathematics and science education at secondary schools. The analysis of the data from the interviews with academics reveals that SI has the potential to improve mathematics and science results at secondary school level. In addition, SI will allow learners to take responsibility for their learning, by allowing learners to identify challenges in their learning, engage in learning activities during SI sessions, and evaluate their learning by establishing what they know and do not know (Paideya, 2011).

The findings also reveal that the SI programme ought to be adapted for secondary school learners who require assistance in building peer-to-peer interaction, motivation and self-efficacy. Supplemental Instruction supervisors would need to assist SI leaders to prepare activities based on developing these skills in learners, such as developing a culture of reflection on concepts that they find difficult to understand.

It was also noted from the findings that teachers were overworked and would not be willing to take on the further responsibility of acting as the SI supervisor. It is therefore suggested that other staff, such as guidance counsellors at school, could be trained as SI supervisors, or that universities could form alliances with secondary schools or other universities who are successfully using SI in their vicinity and develop a weekly after-school SI programme. Initially, university students from the mathematics and science fields could be trained as SI leaders and, thereafter, learners could be trained as SI leaders as was, done in the Swedish project (Mannikko-Barbutiu & Sjogrund, 2004).

An important recommendation that arose from the Swedish study is that all participants in the project should be informed of the SI principles and techniques so that there are no grey areas with respect to expectations and dissemination of the programme. Learners and teachers ought to understand that SI is not a 'quick remedy' for examinations, but rather a process of developing a deep understanding of concepts.

It is also evident from the findings that the SI programme has the potential to work at secondary school level through proper guidance and support of SI leaders. These leaders would in turn need consistent support and guidance from their SI supervisors with respect to subject content and facilitation skills. It is suggested that guidance counsellors or retired teachers could be called upon to monitor and support the SI programme at schools on a regular basis so as to relieve teachers who might already be overburdened with tasks. This could be similar to the successful School Change Project (SCP) initiated in the Free State in 2012. The focus of the project was to improve the mathematics results of learners as well as to encourage more learners to take mathematics as a subject. The poorest achieving schools in the Free State were provided with resources from Master Maths[vi] and the expertise of Mentors. The mentors included Grade 10–12 (mathematics, physical science and accounting) teachers and retired principals, who provided classroom support at least once a week (Haley, 2014).

In addition to providing assistance with the supervision and mentoring of the adapted SI model at secondary school level, the retired teachers could also assist teachers to enhance their pedagogic content knowledge (PCK). PCK refers to the extent to which a teacher can appropriately integrate the use of teaching techniques with the content being taught, and its effectiveness on learner learning (Shulman, 1986). While teacher knowledge is important for the improvement of teaching and learning, teachers need to know both the content as well at the pedagogy behind each section and topic. Shulman (1987:4) defines PCK as "...the category most likely to distinguish the understanding of the content specialist from that of the pedagogue..." Pedagogical content knowledge embraces the comprehension of what makes the understanding of certain subject matter effortless or complicated. This also includes the use of correct language to clearly convey abstract and complex ideas. Essentially, this mentoring would be of benefit to both the teachers at secondary school as well as the learners participating in the adapted SI model. However, one must acknowledge that while this may be an ideal community effort of which to take advantage, it may not be as sustainable as having a designated staff member.

In light of the findings of the 2011 TIMSS report and the current state of knowledge acquisition at school, it appears that learners are taught to adapt their study strategies to the requirements of the examinations rather than to develop a deep understanding of concepts. Supplemental Instruction could thus provide the support that is needed to assist learners in the processing of information resulting in students achieving a better understanding of mathematics and scientific concepts, thus paving the way for further understanding and academic success.

Notes

i. Code used to protect identity of the participants: A1 refers to Academic 1, A4 refers to Academic 4.
ii. Participants refer to both academics and students; see codes next to transcript excerpts.
iii. The students were provided with codes to protect their identity, for example S1 refers to the student who was interviewed first, and S8 refers to the student who was interviewed eighth.
iv. Verbatim quotation was edited for the publication.
v. Verbatim quotation was edited for the publication.
vi. Master Maths is a tutoring franchise developed to assist learners from Grades 4-12. The Master Maths programme involves the integration of personal contact from tutors with interactive computer lessons.

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