From Eersterivier to a PhD: Bridging the gap

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BACKGROUND AND CONTEXTUALISATION

The diverse student intake into higher education in South Africa since 1994 not only changed in terms of numbers but also in terms of preparedness. Various studies indicate that many students, especially those from disadvantaged backgrounds, are increasingly [1]underprepared for higher education (Nel, Troskie-de Bruin & Bitzer, 2009:974; Kgaphola, 1999:38; Quinn, 2003:71).

The poor standard of teaching in [2]black high schools in South Africa is one of many contributing factors resulting in low matriculation pass rates (Le Cordeur, 2010). Many schools lack the resources and infrastructure to produce students who are sufficiently prepared for university (Essack & Quayle, 2007:73), while the content covered in the school leaving examinations also appear to be of little relevance to the studies of many students, especially in the field of science (Mabila et al., 2006, 296). These factors may contribute to the fact that only a small number of students qualify to further their studies at university level. Presently only around 40% of South African learners obtain a National Senior Certificate. Of these learners only one in every eight receives a Grade 12 pass which is good enough to allow them to enter a Bachelors degree programme while only one in seven pass Grade 12 Mathematics and even less pass Grade 12 Physical Sciences (Government Gazette, 2010:13-14).

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[1] For the purposes of this paper under-preparedness is understood as the condition where the knowledge and competencies of the learner entering an educational programme compares negatively with the assumed knowledge and competencies on which that programme is based. Deficiencies in knowledge, skills and academic proficiencies may mask the student's innate ability which can contribute to learners performing below their potential or even failing when they may have the ability to pass (Woollacott & Henning, 2004:3).

[2] According to Essack and Quayle (2007:73) classifying social groups by race is always problematic, and there is little agreement in the literature as to whom the term 'black' refers to. For the purposes of this article, 'black' refers to any person who would have been prejudiced by inequitable conditions under apartheid, i.e. people previously classified as 'African', 'Coloured' and 'Indian'.

Repetition and drop-out rates for students are particularly high, which can indicate that Universities are ill-equipped to accommodate the students that do qualify for higher education (Nel *et al*., 2009:974; Letseki & Maleni, 2007:2-4). Although South Africa has the highest number of tertiary students in sub-Saharan Africa, fewer than two in every 10 students actually graduate (Mabila & Malatje, 2006: 296).

Since a successful transition from school to university is crucial for academic success, many higher education institutions, such as Stellenbosch University (SU), are attempting to 'mind the gap' between school and university in a responsive manner by expanding their bridging programmes (Hay & Marais, 2004). These programmes aim to address the gap between secondary and tertiary institutions and to compensate for the under-preparedness of students by providing them with additional support in preparation for their mainstream studies (Essack & Quayle, 2007:73). Many different terms are used for these interventions. For the purposes of this paper bridging refers to helping underprepared students to gain access to tertiary institutions, to bridge the gap in knowledge and skills and also to provide adequate foundations for learning (Woollacott & Henning, 2004:4).

THE SCIMATHUS BRIDGING PROGRAMME

SciMathUS (the Science and Mathematics Programme at Stellenbosch University) is an intensive, holistic, integrated, year-long bridging programme. The programme started in 2001 and currently caters for 100 talented and motivated black students each year. These students have been disadvantaged by the country's legacy and therefore did *not* qualify for admission into higher education or a selection course. SciMathUS thus provides access to tertiary studies to a big pool of black students who have a far greater potential than indicated by their high school marks (Grayson, 1997:121; Downs, 2010:98).

The programme further addresses the shortfall in South Africa of black professionals in sought after fields such as health and natural sciences, engineering, technology and other related professions also referred to as the intellectual engine of economic development (Hay & Marais, 2002:61; Bitzer, 2010:303; Essack & Quayle, 2007:72,74). The SciMathUS programme accordingly recruits and prepares disadvantaged students for university studies mainly in the Natural, Health, and Economic and Management Sciences.

The voices of 42 former SciMathUS students which formed part of a PhD study during 2005 and 2007 will be presented throughout the paper to indicate the extent to which some of the aims of the programme appear to have been met.

Student selection

Prospective students are recruited from across the whole country. These students have to complete an application which includes their Grade 11 and their final National Senior Certificate (NSC) results, their biographical detail and their personal motivation for wanting to attend the programme. The application process also includes a questionnaire regarding information on their personal and school circumstances, financial details, their need for accommodation and a confidential report by the school to motivate why these students should be accepted into the programme. Furthermore, personal or telephonic interviews are conducted by the programme manager and selected staff members.

A constant effort is made to find scientific ways to determine the potential of prospective SciMathUS students and to recruit the students who would most likely be successful in the programme and at their future studies (Smit, 2010). Many authors have mentioned how difficult but also how crucial it is to identify the potential of students from academically disadvantaged backgrounds (Downs, 2010: 98).

The SciMathUS student

At SciMathUS students are viewed as total beings, which ties in with the ecosystemic perspective of humanity (McCown, Driscoll, & Geiger Reap, 1996:27). Bronfenbrenner's (1990) ecological systems theory, which looks at development within the context of the system of relationships that form the learner's environment, emphasizes that in order to understand the learner, one must not only look at the learner and his immediate environment, but also at the interaction of the larger environment (Berk, 2000:23-38). This basically means that the learner is viewed as more than just merely cognition. Every learner functions within specific systems which are dynamically interwoven. The social contexts (such as a family, peer group, school, and community) SciMathUS students come from are therefore acknowledged and respected. Viewing the learner in totality implies that an attempt is made to know not only where the students come from but also who they are.

Peter Bouhuijs (personal communication, March 16, 2006) so fittingly describes the SciMathUS students as "talented but not developed." Students have largely been exposed to traditional teacher-centred, fragmented, content- and product-orientated approaches for most of their schooling years.

"My classes at school is where the teacher stands in front and talks and we do the listening."(Prior to PBL exposure)

For many of them their inadequate background knowledge in core subjects, their underdeveloped cognitive skills such as logical reasoning, critical analysis and interpretations of abstract representations led them to assume that learning comprises rote memorization of facts (Savin-Baden, 2000:93).

"I call my way of studying parroting 'papegaai leer'. I memorize everything precisely like it appears in the text book and write it down so that I can remember it."(Prior to PBL exposure)

"Most of the time I cram my work on the last minute, thinking I won't forget it but at the end of the day I normally forget everything I've studied." (Prior to PBL exposure)

On entering the programme most of them thus have a survival mentality and try to do things the easy way.

"The task of the lecturer is thorough preparation before class, presenting work the easiest way possible, checking progress regularly and thinking about ways to improve it." (Prior to PBL exposure)

It is not uncommon to find that they expect the people who teach them to direct their studies, leaving them dependent, passive and often competitive and defensive (Adendorff, 2006; Engelbrecht, 2001:47; Finucane *et al*., 1998:445-448).

"They (the teachers) must present the work correctly and simply, they must be able to answer all my questions and provide me with a bit of inspiration." (Prior to PBL exposure)

They are usually unable to use each other as learning resources; they are unaware of problem solving skills and are less reflective in their learning and often unable to tell when they understand or do not (Engelbrecht, 2001:47; Johnston & Tinning, 2001).

Their lack of success during their final secondary school years means they are often disheartened and find it difficult to see that their lived experiences and those of others have value. Many also lack a strong work ethic, i.e. they fail to do homework or because of the

intensive nature of the programme regard the time spent in contact sessions as sufficient for their exam preparations (Gayson, 1996:994-995). It is clear that at present the South African school system does not equip everyone that has talent to continue with further study.

Educational philosophy

The philosophy adopted by SciMathUS strives to equip students with the underlying skills and attitudes needed for life-long learning. One of the great strengths of the programme is the existence of a common educational philosophy and instructional approach which reflects a shared way of thinking about the role of the learner and teacher, a shared view on learning, and how and what should be taught.

In order to enhance the students' chances of success in higher education, Problem Based Learning (PBL) was introduced into the curriculum in 2005. PBL is a different philosophical approach to teaching and learning (Charlin et al., 1998:323-330; Limerick & Clarke, 1997:259-274; Newman, 2004:17; Savin-Baden, 2000:19) and an innovative approach to curriculum design and implementation (Hattingh & Killen, 2003:39-40). PBL describes a student-centred learning environment which rests on the assumption that students are not viewed as empty vessels (Freire, 1985:22) but that they come with their own perceptual frameworks, that they learn in different ways, and that learning is an active, dynamic process (Adendorff, 2006).

In PBL learning begins with a problem that needs to be solved and the problem is posed in such a way that students have to work cooperatively in groups to gain new knowledge before they can solve it (Dunlap, 1997:1; Miflin,2004a:50; Savin-Baden, 2000:15; Sonmez & Lee, 2003:1).

"First we were confused because we didn't precisely understand the problem. Then we used each other's knowledge to break down the problem." (After PBL exposure)

This prepares students to think critically, to find and use appropriate learning resources of their own accord and challenges them to "learn how to learn" (Watson, 2005:11).

"I've learnt to think more critically; not just to accept things that are given to me but also to question it." (After PBL exposure)

PBL offers an attractive alternative to traditional education by shifting the focus of education from what staff members teach to what students learn (Burch, 2001:194; White, 2001:69).

Through PBL students are provided with a learning environment where they are stimulated to become more involved and take on more responsibility for the learning process (Dochy *et al*., 2000:25).

"Effective learning is taking responsibility for my studies and making sure that I understand and that I am able to apply my knowledge."(After PBL exposure)

"Yes, there is a change. I realized not everything can be taken for granted like we did at school but that I have to work very hard and think well." (After PBL exposure)

The emphasis placed on self-directed learning within the PBL philosophy encourages students to reflect upon and control their own learning activities; skills which are conducive to lifelong learning (Johnston & Tinning, 2001:161).

All the educational theories which underpin PBL can be considered to be examples of constructivism (Tynjälä in Newman, 2004:16). Constructivism is a philosophy that is student-centred and guided by certain beliefs about learning (Drake, 1998:152). It is based on a view in which 'knowledge' is not absolute, but is actively constructed by the student based on previous knowledge and overall views of the world (Baker, 2000:260; Oxford, 1997:36). In the SciMathUS context PBL can be thought of as a combination of cognitive 'scientific' and social constructivist theories (as developed by Piaget and Vygotsky) in which learning is not only constructed by students personally as they try to make sense of their realities but where learning is also viewed as a social process. By combining these different perspectives, learning is not viewed as an activity that only takes place within an individual, nor is it a passive development of behaviours that are shaped by external forces but it occurs when individuals are engaged in social activities (Kim, 2001:1). Social constructivism therefore suggests that knowledge is both socially and cognitively constructed where the knower interprets and constructs a reality based on his experiences and interactions with his environment (Von Glasersfeld, 1995:7) given that mathematical and scientific knowledge construction are both an individual and a social construction process (Ernest, 2005:4).

"I like to work as a team, but there are certain things that I like to discover for myself."(After PBL exposure)

This social-constructivist learning environment further guards against too much teaching and not enough learning taking place (DiCarlo, 2009:257-264; Lujan & DiCarlo, 2006:17-22). The scope of the content is therefore restricted and the focus becomes more on the

development of conceptual understanding which encourages deep rather than surface approaches to learning.

"Rather than memorizing I try to understand the work that stays much longer in my memory." (After PBL exposure)

"At school there is not that much time to look at things in depth unless it's on your own time which I don't always have." (After PBL exposure)

Content remains important, but there is more emphasis on the *process* of learning (White, 2001:70). At SciMathUS it is believed that the educational philosophy adhered to in the programme provides students with a more realistic picture of the academic challenges that they have to face in higher education, encouraging them to become more active, reflective and self-directed.

"We loved it. It took us beyond the text book and we find it prepares us for the outside world." (After PBL exposure)

Instructional principles

Based on the educational philosophy of the programme, the instructional principles adhered to at SciMathUS share the following key features outlined by Newman (2004:14-15), Barrows (1996:3-6) and Boud (in Savin-Baden, 2000:17-18).

Learning is student-centred with an emphasis on students taking responsibility for their own learning. Students take the role of active problem-solvers rather than passive students waiting to be spoon-fed (Baker, 2000:258; Charlin *et al*., 1998:323-330; Mierson, 1998:16; Newman, 2004:115; Savin-Baden, 2000:17-18).

"I take my work in my own hands now and don't wait for others to spoon feed me." (After PBL exposure)

"My methods of studying is different, I'm more active now."(After PBL exposure)

PBL involves a shift in the curriculum which typically involves three shifts, namely from content coverage to problem engagement; from the role of lecturing to the role of coaching and mediating; and from students as passive learners to active problem-solvers (Finucane *et al.*, 1998:445-448). This is quite different from most university teaching approaches which concentrate on the transmission of factual knowledge (Yeung; Au-Yeung; Chiu; Mok, & Lai, 2003:237). It is however important to note that although PBL does not deny the importance of 'content' it does deny that content is best acquired in the abstract, in vast quantities, and in a purely prepositional form, to be brought out and 'applied' much later to problems. Problem-

based learning therefore requires a much greater integration of 'knowing that' with 'knowing how' (White, 2001:69).

Problems form the organizing focus and stimulus for learning. The principal idea behind PBL is that learning should be organized around conceptually ill-defined real-world problems, rather than just around subjects (Charlin *et al*., 1998:323-330; Limerick & Clarke, 1997:259-274; Raine & Symons, 2005:6; Van den Bosch & Gijselaers, 1993:31).

> *"I have experienced that my studies are real. It helps us to grasp the relevance of math and how science occurs in our daily lives." (After PBL exposure)*

Lecturers are facilitators or guides rather than disseminators of knowledge. The role of the lecturer can be understood in terms of meta-cognitive communication which implies that the lecturer role models asking the kind of questions that students should be asking themselves to better understand and manage the problem until students are eventually ready to take on this role themselves (Baker, 2000:261; Engelbrecht, 2001:12).

Learning occurs in small groups. PBL is a collaborative form of learning (Limerick & Clarke, 1997:259-274) in which students work cooperatively in small groups of four to five students (Dochy *et al*., 2000:25; Raine & Symons, 2005:6) to seek solutions to real world problems (Mierson & Freiert, 2004:15). This promotes the students' self-esteem while they serve as a source of information and help and learn from each other (Bolhuis, 2003:331).

> *"I have learned that I don't trust myself but I have confidence now because I was not shy to say what I was thinking."(After PBL exposure)*

Through collaborative group work and accessing a wide variety of resources, students also experience and develop an appreciation for multiple perspectives (Williams, 2001a:93) while individual contributions are respected in a context of consensus building (De Villiers & Queiros, 2003:116).

> *"Listening to other people's views and how they interpret the problem can make you learn a lot."(After PBL exposure)*

> *"It's amazing how someone can see something that you can't see."(After PBL exposure)*

PBL recognizes that *knowledge transcends artificial boundaries* by highlighting the interconnections between disciplines or subjects and the integration of concepts (Duch, Groh & Allen, 2001:7).

> *"The lecturers wanted us to see that real life problems have a strong correlation with the math and science we do here in SciMathUS." (After PBL exposure)*

New information is acquired through self-directed learning (SDL). Through PBL students are provided with a learning environment where they are stimulated to become more involved and take on more responsibility for the learning process (Dochy *et al*., 2000:25). The emphasis placed on self-directed learning within the PBL philosophy therefore encourages students to reflect upon and control their own learning activities; skills which are conducive to lifelong learning (Johnston & Tinning, 2001:161).

Assessment is congruent with learning objectives. Moving to a student-centred, cooperative learning format requires rethinking how to assess student learning. In PBL a change in focus from merely staff assessment of outcomes of learning to student self- and peer assessment is evident (Boud in Savin-Baden, 2000:17-18).

Prior experience is acknowledged. In working on problems through small-group discussions students' prior knowledge and experience are activated (Schmidt *et al*., nd:23) and learning starts with where the learners are which promotes the students' self-confidence.

"We needed old knowledge to solve the problems." (After PBL exposure)

"I think I am now able to reason things out by myself. I trust my own thinking and don't rely on other people's brains."(After PBL exposure)

"I always focused on the right answer which stopped me from answering in class or I said nothing when I didn't understand something. This is slowly starting to change." (After PBL exposure)

In short, PBL in its pure form treats teaching and learning as a problem-centred, collaborative, integrated, interdisciplinary process conducive to lifelong learning (Van Kampen, 2005:38; Johnston & Tinning, 2001:161).

Holistic instructional approach

To equip SciMathUS students to be successful in higher education a holistic approach to their education is followed. The holistic curriculum includes the following core subjects, Mathematics, Physical Sciences, Accounting, as well as the following additional subjects, Academic Language and Thinking Skills, Study and Life skills, Computer Literacy and Statistics. As the previous programme manager, Dr. Wynoma Michaels (2005), explained: "At SciMathUS we want to develop the multiple facets of each individual to the extent that each person is sufficiently skilled and empowered to become a productive member of the Commerce, Science, and Engineering professions in South Africa which is the reason for the holistic approach of the programme".

Students are able to choose between a Science and Mathematics stream and an Accounting and Mathematics stream. Students who choose the Science stream rewrite both the Physical Sciences and Mathematics examinations of the NSC at the end of the year. Those enrolled in the Accounting stream rewrite the Mathematics NSC examination but write an internal Accounting examination as they follow the curriculum of the extended degree programme offered to first year students in the Faculty of Economic and Management Sciences. Because of the different levels of the students a maximum of 25 students are taken in per class.

Curriculum design

Akin to Grayson (1996:995), "curriculum" will be used in the broadest sense to mean all the elements of the learning environment. As mentioned previously, PBL was introduced into the curriculum in 2005 in order to enhance the students' chances of success in higher education. An adapted version of PBL, or a Hybrid PBL approach for the specific needs of the programme was needed which would gradually make PBL an integral part of the existing curriculum. One of the most important issues in restructuring the curriculum was taking into consideration the Grade 12 and first-year curriculum for Mathematics and Physical Sciences. This was followed by a c*urriculum dissemination* phase during which the facilitators and students were prepared for the intended change. During the c*urriculum implementation* phase the Hybrid PBL approach was applied in practice, followed by a *curriculum evaluation* phase during which the effectiveness of introducing a Hybrid PBL approach into the SciMathUS curriculum was assessed in terms of measurable outcomes (Babbie & Mouton, 2001:343; Carl, 2002:54; Wood & Mack, 2001:2).

As a result of the evaluation of the curriculum implementation phase the following curriculum structure was developed. The curriculum consists of 14 weekly hours of Mathematics, 14 hours of Physical Sciences, 10 hours of Accounting, 4 hours of Statistics, 4 hours of Academic Language, Thinking, Life and Study skills and 2 hours of Computer Studies. Contact sessions only take place in the mornings from 8h00 to 13h00 in order for students to acquire a sound knowledge base in the core subjects, however lecturing is minimised. This is coupled with afternoon sessions from 14h00 to 17h00 which comprise of the use of appropriate learning technologies (e.g. tutorials and computer-assisted learning), discussions, small group work on PBL or other subject related problems, individual consultations with lecturers, and practical sessions in the laboratory. During the afternoon sessions students integrate or reinforce concepts learnt during the morning sessions, which enriches the syllabus

and allows students to explore problems which commensurate with their developing understanding of these subjects. This contributes to students having a sound understanding of key concepts in the curriculum, which would also be relevant to their university studies.

Nature of instructional practices

In an effort to make the transition to a more student-centred approach, the SciMathUS lecturers involve students as participants in a shared situation where the lecturer performs the role of facilitator in order to assist the students to become more self-directed and teacher-independent in their learning (Allen *et al*., 1996:44; Barrows, 1992:12; Dolmans *et al*., 2002:173).

> *"We want to stand for ourselves, put our own effort into it. We know we can conquer these challenges with less support … we're supposed to function independently as learners." (After PBL exposure)*

> *Sometimes we need to be left alone to figure out what we don't understand and how we can then come up with our own solutions." (After PBL exposure)*

In order to prepare students for self-directed learning, a two-week orientation programme is provided during the first week of the programme. This is facilitated by the Academic Language and Thinking Skills facilitator. The orientation programme includes an introduction to the PBL philosophy and approach, the PBL process and learning cycle, the role of the student and facilitator, the principles and practices of learning in groups, skills in organization, and self and peer assessment (Savin-Baden, 2000:29). Students are thus equipped to relinquish their role of passive recipients and become active constructors of knowledge.

During the design of the curriculum the facilitators of all the subjects work together to integrate the content and skills needed by the students. Mathematics and Physical Sciences are taught in an integrated way, by partly making use of PBL. This entails that the students start from practical problems and identify their own conceptual needs while working collaboratively in groups (Raine & Symons, 2005:6; Van den Bosch & Gijselaers, 1993:31). During this process the facilitators help the students link the content in a specific problem to their prior knowledge and then build the learning and understanding process from there onwards.

> *"PBL shows you how your subjects are related which improve understanding."(After PBL exposure)*

One rationale for the integrated approach is to rid the students of the tendency to place each subject in a box, isolated from all the other subjects. Students thus realise that there is a unity to science and mathematics, a common underlying way of thinking and approaching problems. In short, the basic steps of the PBL process involve encountering a problem, identifying learning issues in an interactive process, self-study, applying newly gained knowledge to the problem, and summarizing what has been learned. The process concludes with students evaluating the experience.

"PBL encouraged us to apply our knowledge instead of working out of a text book.
It creates a clear picture
about textbook theory and real life problems.
Math and science happens in everyday life." (After PBL exposure)

Students' self-directed learning time is the period between the problem presentation and problem discussion meetings. Here individual students or small groups seek information to satisfy the identified learning issues and then restructure the problem based on their new knowledge. The problems have natural break points at which the facilitators often intervene when needed without hindering students' initiatives. During these breaks, whole-class discussions led by a facilitator are used to clarify common misconceptions and encourage groups to compare notes on their progress. This encourages meta-cognition.

"We asked ourselves what we didn't understand and what caused the misunderstanding." (After PBL exposure)

If we didn't understand we used a different way of approaching it." (After PBL exposure)

"It was important to think before we just leap in." (After PBL exposure)

Emphasis is placed on the provision of positive learning experiences to students who are often disheartened by the traditional school system by building on their strengths and prior knowledge and improving their skills of 'learning to learn' (Barrows, 1996:5; Burch, 2001:194; Seltzer *et al*., 1996:84; Tynjälä, 1999:427).

"I learnt that I am a very bright person and I should never underestimate my abilities." (After PBL exposure)

"I changed a lot. I'm wiser. I have taken more responsibility for my work. I'm more focused on my goals, something that I never did in the past."(After PBL exposure)

"I learnt I have the right to express my own opinions." (After PBL exposure)

As a means to help students integrate their learning they are taught for transfer by providing them with opportunities where they can transfer what they have learnt in one context into another context. Since the facilitators are aware of what is going on in each other's courses, it is more likely that transfer will occur.

"In order to show us that the work we do inside the classroom doesn't end in the class but we can implement the same skills in the outside world." (After PBL exposure)

Both formative and summative evaluation is used to assess the performances of students. Assessment usually occurs within a short time span to ascertain quickly whether or not students have grasped the course content and whether they are applying the appropriate skills to provide a viable solution to a problem. During the first semester feedback on assignments or problems are very detailed. This includes written comments by the different facilitators and panel discussions to help students when they have not understood the material or have not applied the appropriate skills to problems. In order to assist facilitators during this process, assessment checklists are provided with additional guidelines. Another form of assessment used is group tests. Students write individual tests, contributing 80% to their mark and then rewrite the same test in groups of three which then contributes 20% to their test mark. The rationale of the group tests is that learning will take place via discussions and reflections which mean assessment and learning is integrated in such a way as to support rather than measure learning (Poikela & Poikela, 1997:19).

Regular staff meetings are held to iron out practical problems and to reflect on the direction of the programme and the curriculum. Research meetings are held once a week. The research team consists of five lecturers. Members of the team are asked to reflect daily on their classroom practices. A reflection log on Google docs makes it possible for all the lecturers to access and comment on each others' reflections. These reflections are thus discussed on a weekly basis; specific literature regarding reflections is studied and recommendations for improvements are then suggested via a team approach. The research team is also involved in writing papers and presenting at conferences to share their experiences and lessons learnt and learn from others.

SUPPORT STRUCTURES

As mentioned previously, since various factors impact the successful transition from school to university the SciMathUS programme adopts a holistic, integrated approach and has the following additional support structures in place, namely social, emotional, cultural and financial structures (Nel *et al.*, 2009:985).

Socio- emotional support

Many of the students come from poverty ridden townships and rural areas and face many challenges and hardships. A support network, especially with regard to the emotional wellbeing of students, is therefore important. Students are consulted individually in collaboration with the Centre for Student Counselling and Development. Counselling consists of the development of life skills, vocational and personal counselling. Since students also rely on the support of their parents for success, parent involvement is highly encouraged.

Given that residence accommodation plays a major role in students' academic and social integration (Nel *et al*., 2009:987), thirty eight students are accommodated free of charge in student houses each year which exposes them to campus life and helps them gain a realistic view of the university environment.

Financial support

Many of the students are in need of financial support which is provided in the form of stipends and food vouchers. Support is also provided with bursary applications in collaboration with the Career Office at SU and students are well informed regarding realistic career choices and procedures to follow for financial support during their future studies. The programme also strives to stay in contact with former students in order to assist them financially during their further studies since one of the biggest contributing factors for the high drop-out statistics during studies are economic reasons (Downs, 2010:105). If the programme cannot assist the students financially they are helped to find assistance elsewhere.

METHODOLOGY

In an attempt to ascertain whether the SciMathUS bridging programme is addressing the gap between secondary and tertiary institutions and to compensate for the under-preparedness of students, this paper focuses on the implementation and the results of the SciMathUS programme. The main research questions were to determine the trends in the number of

SciMathUS students registering for tertiary studies and graduation at SU and to determine whether exposure to the PBL approach encouraged the use of self-directed learning skills (reflected in the student voices throughout the paper). It is hoped that this would address the shortage of published data to demonstrate the effect of bridging programmes at a university level in southern Africa, in terms of number of black graduates from an academically disadvantaged perspective (Downs, 2010:100).

In order to ascertain whether proposed outcomes are being met, the success of the programme is assessed by comparing access and throughput rates in higher education; making use of the NSC (National Senior Certificate) examination results pre- and post SciMathUS and the use of self-directed learning skills (SDL) before and after being exposed to PBL.

Evaluation, sometimes referred to as programme evaluation (Rossi, Lipsey, & Freeman, 2004:2) thus forms an essential part of the programme. The purpose of the evaluation is ongoing, formative and developmental in nature focusing on programme improvement (Babbie & Mouton, 2001:338,345; Mertens, 2005:232; Rossi *et al.*, 2004:44) as well as summative (Babbie & Mouton, 2001:357) to ascertain whether SciMathUS is bridging the gap between schooling and university access and success in higher education. The approach to programme evaluation is a case study method where a description of what the SciMathUS programme looks like and what results have been achieved are presented.

The academic histories of SciMathUS students at SU were collated and summarized up until December 2009. Although some students have pursued their studies at other South African tertiary institutions, their graduation success was excluded in the present study because of difficulties in obtaining information. In addition, the matriculation marks of the SciMathUS students, pre and post SciMathUS, from 2001 to 2009 were collated and analyzed. Data on the number of black students enrolling at SU from 2003 to 2005 for a three or four year course were obtained from the Tracking System of the SU. Data on access tests written in 2009 by 34 students, pre and post SciMathUS, were obtained from the Centre for Prospective Students. For comparison, data were expressed as frequencies per year and as percentages. In order to determine the use of self-directed learning skills, data from the 2007 student cohort were generated through semi-structured focus group interviews with students and lecturers, questionnaires and classroom observations and the application of the Inventory of Learning Styles (ILS) questionnaire (Vermunt, 2004a, 2004b). The *qualitative data* from the various

observations made by the tutors, the researcher and students represented throughout the paper were analysed using the thematic and content analysis procedure of open coding as described in Berg (1995:185) and Frank and Barzilai (2004:46).

RESULTS

In the early years of SciMathUS 40 and even less students were admitted to the programme, but this increased to more than 100 students since 2009 (see Table 1).

Table 1.Number of SciMathUS students still progressing at SU in 2010.

YEAR IN SCIMATHUS	Registered in SciMathUS	Completing the programme	Registered for first year at SU	Medicine	Engineering	Sciences	Accounting	Commerce	Other	Total currently registered
2001	40	35	10							
2002	57	57	19							
2003	32	32	31	2			1		1	4
2004	78	71	58	3	6	3	1	3		16
2005	70	57	57	3	6	3		3		15
2006	53	46	35	1	1	5	1	3	2	13
2007	48	36	39	0		13		10	7	30
2008	61	59	56	3	8	15	3	10	2	41
2009	104	79	56	2	7	26	2	12	7	56
TOTAL	543	472	361	14	28	65	8	41	19	175

In total 543 students have enrolled in SciMathUS over 9 years. Of these students, 472 completed the programme successfully, that is, passed the NSC examination with exemption. Of the students who completed the programme successfully 76% (361/472) registered at SU for their first year. Many of the remaining students were accepted at other higher education institutions. Currently 175 SciMathUS students are registered at SU for studies mainly in

sought after fields with the highest amount of students studying in the sciences. Most of these students would not have had access to tertiary studies.

One student currently busy with his studies in medicine was invited to become a member of the Golden Key International Honour Society. The Society focuses on academic excellence, leadership development and community service. The Society provides academic recognition to high achieving students. This student was also selected to the house committee of his residence. Five years after completing the SciMathUS programme another student is about to finish his masters degree in medical physiology. His research evaluates the effects of drugs designed to prevent heart disease. This student entered SciMathUS with 45% for Physical Sciences and less than 40% for Mathematics.

Of the 2001 SciMathUS cohort who registered at SU, 30% (3/10) obtained degrees while for the 2002 cohort, 47% (9/19) obtained degrees. Twenty per cent (37/ 181) of the students from the 2003 to 2006 cohort obtained degrees while 27% (48/181) are still progressing (see Table 2).

Table 2.Number of SciMathUS students who had graduated at SU by 2010

YEAR IN SCIMATHUS	Registered for first year at SU	Still progressing	Graduated
2001	10		3
2002	19		9
2003	31	4	11
2004	58	16	12
2005	57	15	11
2006	35	13	3
TOTAL	210	48	49

The number of SciMathUS students from the 2001 to 2006 cohorts that graduated in the various faculties at SU is shown in Table 3.

Table 3. Number of SciMathUS students registered and graduated at SU from 2001 – 2006 by faculty.

Faculty	Graduated	Post Graduated
Medicine	2	
Health Sciences (other than medicine)	5	
Engineering	4	
Science	12	4
Commerce	17	3
Other	9	3
TOTAL	49	10

The two students who graduated as medical doctors are two women one from the Eastern Cape and one from Limpopo. Both of these students are currently busy doing their internship in the communities they grew up in. One of the students reported to the Mail and Guardian (25th June 2010) that it is her dream to continue working in the public sector. She said: "It means I would go where most of the population is. It's going where the action is and that's what I want. My job is to help those people who are too poor to afford private doctors." The post graduate qualifications of other SciMathUS students include Teachers' Diplomas and Honors degrees in Science and Accounting.

As seen in Table 4 the programme has contributed towards the number of black students registering at SU with contributions of 2,3% in 2003, 3,45% in 2004 and 7,39 % in 2005. Three per cent of SU graduates from 2001 to 2004 are former SciMathUS students indicating that SciMathUS is positively contributing to the diversity profile of SU.

Table 4. Black students enrolled at SU for a three or four year course

	2003	2004	2005
Number of black students that enrolled at the University of Stellenbosch	739	841	744
Number of SciMathUS students that enrolled at the University of Stellenbosch	17	29	55
SciMathUS as a Percentage of students	2.30	3.45	7.39
Number of black students that graduated in 5 years at the University of Stellenbosch	312	348	285
Number of SciMathUS students that graduated in 5 years at the University of Stellenbosch	9	11	12
SciMathUS graduates as a Percentage of graduate students	2.9	3.2	4.2

In 2009 thirty-four SciMathUS students wrote the access tests of SU, pre and post the programme. For Mathematics an average of 15 percentage points increase was measured while for Physical Sciences the average increase was 9 percentage points. Comparing the pre and post SciMathUS NSC results the average improvement per subject (Mathematics and Physical Sciences) ranges between 10 and 20 percentage points. This results in the students gaining access to tertiary studies.

From the student reflections from the 2007 cohort which formed part of a PhD study (Malan, 2008) it appeared that exposure to a PBL philosophy did encourage the use of self-directed learning skills.

DISCUSSION

A Department of Education study on graduation rates at South African higher education institutions indicated that only 30 per cent of first-time entering students had graduated after five years of study (Nel *et al*., 2009:974) whilst the black completion rate in higher education is less than half the white completion rate (Scott, Yeld & Hendry, 2007:17). The throughput figures of SciMathUS indicate that it is faring well in comparison with the national graduation rates and specifically the completion rate for black students. Improving throughput however remains a priority.

The traditional teaching methods students were exposed to with a high focus on teacher control and transfer of knowledge (associated with reproductive learning patterns) enhances

learner dependency, a lack of understanding, reflection and self-direction. PBL, on the other hand advocates a more innovative learning environment. Here the emphasis is on active, constructive and self-regulated learning which encourages more self-directed learning patterns with a gradual transfer of control over student learning processes from external regulation to self-regulation albeit at a slow and gradual process (Malan, 2008). Student responses from the 2007 cohort indicated that exposure to PBL does encourage the use of more self-directed learning skills. With regard to deep-processing learning strategies, the student responses show that exposure to the PBL approach promotes the use of deep-processing learning strategies, typified by processing the subject matter critically and self-regulating learning processes whilst making less use of surface approaches to learning such as memorizing. In addition, the students appear to make more use of meta-cognitive self-regulating activities such as planning, testing their outcomes and adjusting and reflecting on their solutions. This is congruent with the move towards the use of more self-directed learning skills.

Since various factors impact the successful transition from school to university, a contributing factor to SciMathUS' success is the holistic, integrated nature of the programme with the necessary social, emotional, cultural, financial and academic support structures in place.

However the challenge is finding alternative mechanisms to identify and select disadvantaged students with the potential to succeed in mathematics and science-based studies, since school performance marks of students from educationally disadvantaged schools are not necessarily the best predictors of academic success (Huysamen, 2000; Grayson, 1997). Another challenge is finding sponsors to fund the programme since SciMathUS is not a credit-bearing programme.

According to Grayson (1997:107), within bridging programmes content should be restricted in scope to allow the inclusion of cognitive and practical skills and to focus on the process of learning and should be covered in depth to promote conceptual understanding. Because of the vast amount of work that must be covered during the allotted time, the NSC curriculum does not always allow one to start at the student's level. The programme aims not only to bridge the gap between school and tertiary studies but also to create a transition process for the student. Ideally teaching should start where the students are and handle what is accessible to them (Grayson, 1996:1000).

Despite these challenges the results indicate that the SciMathUS programme is making a meaningful contribution in building the capacity of promising tertiary students. The figures

mentioned previously indicate that SciMathUS is fairing well in comparison with the national graduation rates of first-time entering students and specifically the completion rate for black students, considering that SciMathUS students would not have gained access to higher education institutions due to their poor matriculation results.

The programme unlocks the potential of black students and contributes positively to the diversity profile of Stellenbosch University whilst addressing the shortfall of black professionals in South-Africa in sought after fields.

CONCLUSION

Bridging programmes such as SciMathUS can play a crucial role in bridging the gap between school and university. Since a large number of South Africa's learners are not exposed to opportunities to realize and optimize their potential it is hoped that a programme such as SciMathUS will not only enable higher education institutions to fulfill their mandate in serving the socio-economic needs of the country but also touch and transform the individual lives of the learners and break the poverty cycle. SciMathUS is a symbol of Stellenbosch University's pedagogy of hope!

"SciMathUS did not do that I expected, it did more: it helped me to learn to think for myself; learn to question things in a constructive manner and ultimately become a better person."

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