AN INVESTIGATION INTO THE EXPERIENCES OF TEACHERS USING THE SINGAPORE MATHEMATICS CURRICULUM IN SOUTH AFRICA

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ABSTRACT

The purpose of this case study was to investigate the experience of six Foundation Phase teachers implementing the Singapore Mathematics Curriculum (SMC). The study makes use of Kilpatrick, Findell & Swafford"s (2001) framework for teaching for mathematical proficiency as a conceptual lens to analyse teaching practice in the classroom. The study took place in two schools currently implementing the SMC in East London, in the Eastern Cape Province of South Africa.

This qualitative study was framed within an interpretive paradigm. It relies on data collected in semi-structured interviews, individual questionnaires, focus group interviews, journals and presentations.

In general, the SMC was well received, and the participating teachers isolated the following as particularly positive features of their experience:

- The teachers and students were enjoying the discovery of mathematics using a variety of manipulatives as stipulated when using the SMC;
- The use of the model method, a specific feature of the SMC, to solve problems helped students visualise the problem;
- The teachers" understanding of teaching for mathematical proficiency was enhanced;
- The spiral curriculum informed teaching practice by allowing for building on to concepts already mastered, creating a logical flow of ideas and careful progression;
- Whilst the SMC provides a more structured approach to the teaching and learning of mathematics, it provides constant opportunities for creativity and logical thinking; and
- The change in attitude of both students and teachers has resulted in a greater confidence when non-routine, open-ended problem solving activities are engaged in.

From a critical perspective the participants found the following problematic when implementing the SMC:

- The teachers felt that there was insufficient drill and practice once the concept was understood. More practice and exercises were called for;
- The whole class teaching approach with every student having a textbook and workbook pertaining to the lesson required a change to classroom management; and
- To obtain a deeper understanding of number concepts was time consuming and re-teaching the weaker students called for additional time and adjustments to the timetable.

ACKNOWLEDGEMENTS

I certainly would not have managed to carry out this research without the support of many people. I wish to express my sincere gratitude to the following persons who have contributed towards the completion of this thesis.

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I would like to acknowledge the Eastern Cape Department of Education who granted me a bursary to assist me financially in my studying.

Thank you to my family and friends for their understanding, patience, encouragement and moral support throughout this study. I am particularly indebted to my husband Mike for his unconditional support and belief in my ability.

Thank you Lord for new opportunities each and every day to learn and grow in the journey of life.

DEDICATION

This thesis is dedicated to my mother, Sheila Sutton, who is my friend, my mentor and who has given me all the encouragement and support in everything that I ever set out to do. For her nurturing way of allowing me to be who I am, coupled with her unconditional love, I am deeply grateful.

DECLARATION OF ORIGINALITY

I, Beverley Dawn Keth, (Student number g00k3246) declare that this thesis *investigating the experiences of teachers implementing the Singapore Mathematics Curriculum in South Africa* is my own work written in my own words. Where I have drawn on the words or ideas of others, these have been acknowledged in the manner required by the Rhodes University Department of Education Guide to referencing.

Beverley Dawn Keth — 30 November 2011

(Signature) — (Date)

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LIST OF ACRONYMS

APL	Advanced Proficiency Level
CAPS	Curriculum and Assessment Policy Statements (South Africa)
DBE	Department of Basic Education (South Africa)
DOE	Department of Education (South Africa)
ELL	English Language Learners (United States)
FG	Focus Group
GDE	Gauteng Department of Education (South Africa)
GET	General Education and Training band (South Africa)
NCGS	National Coalition of Girls‟ Schools
NIE	National Institute of Education (Singapore)
NJ ASK	New Jersey Assessment of Skills and Knowledge (United States)
PCK	Pedagogical Content Knowledge
PL	Proficiency Level
PPL	Partial Proficiency Level
PUFM	Profound Understanding of Fundamental Mathematics
MOE	Ministry of Education (Singapore)
MMTP	Model of Mathematics Teaching Proficiency
MP	Mathematics Proficiency
NCTM	National Council of Teachers of Mathematics (USA Research Council)
NCS	National Curriculum Statements (South Africa)
PSSM	Principles and Standards for School Mathematics (United States)
RNCS	Revised National Curriculum Statements (South Africa)
SBI	Standards‟ Belief Instrument
SMC	Singapore Mathematics Curriculum
TIMSS	Trends in Mathematics and Science Study (originally named the Third International Mathematics and Science Study)

APPENDICES

CHAPTER ONE
INTRODUCTION AND BACKGROUND TO STUDY

> Tell me mathematics, and I will forget; show me mathematics, and I may remember; Involve me...and I will understand mathematics. If I understand mathematics, I will be less likely to have math anxiety. And if I become a teacher of mathematics, I can thus begin a cycle that will produce less math-anxious students for generations to come.
>
> W.V. Williams (1988)

1.1 INTRODUCTION

I have always loved teaching mathematics and considered my own teaching practice as one that promotes a love for and an understanding of number and shape in my students. The purpose of this study is to investigate how research-based activity can inform and improve teacher practice in the Foundation Phase of schooling after the implementation of the Singapore Mathematics Curriculum (SMC). In this chapter I explain why the study was undertaken, provide a rationale for it, and introduce some key features of the SMC. I make use of the framework for teaching for mathematical proficiency designed by Kilpatrick, Findell and Swafford (2001), because it provides a useful conceptual lens for the analysis of teaching practice. Before providing an overview of the thesis I briefly review the research methodology employed.

1.2 BACKGROUND TO THE STUDY

This study was primarily motivated by a desire to enhance the quality of teaching and learning mathematics in the Foundation Phase of schooling. South Africa has undergone three changes of curriculum since becoming a democratic country in 1994, and given the consistently poor mathematics results from our schools still faces many challenges. In order to confront these, in consultation with my school"s Governing Body, I investigated school curricula from other parts of the world that have been deemed successful. After careful consideration and looking at the results of Singapore, the current

leaders in mathematics education according to TIMSS,[1] our School Governing Body took the decision to pilot the Singapore Mathematics Curriculum (SMC) at our school. The introduction of a new curriculum provided an opportunity for teachers to have more professional space and autonomy to reflect upon and change their practice. This opportunity inspired this research project, in which I critically explore how the implementation of the SMC in the schools under investigation has informed teaching practice.

1.3 THE GOAL OF THE RESEARCH

The goal of this research is to investigate teacher practice and the experience of selected Foundation Phase teachers in implementing the Singapore Mathematics Curriculum in South Africa.

1.4 THE SINGAPORE MATHEMATICS CURRICULUM (SMC)

Problem solving is viewed as central to the teaching of mathematics. A distinctive feature of the SMC is the use of the Model Method in solving problems. The Model Method (Singapore. Ministry of Education [MOE])[2] is a pedagogical strategy introduced to students from an early age to help them visualise what the mathematical problem is. The method is used to develop students‟ fundamental mathematical concepts and proficiency in solving basic mathematics word problems. Through the construction of a pictorial model to represent known and unknown quantities, the visualisation of a problem is facilitated, creating opportunities for students to construct their own models in written form.

To enhance thinking skills, various heuristics were introduced. Heuristics are distinctive strategies which students are taught to use when approaching a problem in mathematics, especially when a solution is not obvious.

An important factor in the SMC is the availability of effective and quality resources. The use of manipulatives to work with number concepts, for example, supports a concrete approach to learning. This is part of a three-step approach to learning espoused by the SMC. It entails working from a concrete, hands-on discovery-type approach to a semi-concrete stage making use of pictorial representation of the same number concept, before proceeding to a third stage where students are

[1] Trends in Mathematics and Science Study (TIMSS) was originally named the Third International Mathematics and Science Study.
[2] Singapore, Ministry of Education (MOE)

expected to think and work in the abstract. Kilpatrick et al. (2001, p. 354) concur that "manipulatives can enhance students" understanding and also help students correct their own errors". Additional resources central to the SMC include the teacher"s manual and a textbook and workbooks per year group, including a homework book.

1.5 THE CONCEPTUAL FRAMEWORK FOR THIS STUDY

The work done by the National Council of Teachers of Mathematics (NCTM, 1991) and the writings of Kilpatrick et al. (2001) on teaching for mathematical proficiency inspired my thinking and research into how the SMC has the potential to inform the classroom practice of our teachers. I intend to use Kilpatrick et al. (2001) to formulate a conceptual framework for investigating what selected Foundation Phase teachers are doing within their classroom practice in the context of the SMC, because the successful implementation of a mathematics curriculum is directly influenced by the teaching practice of the teachers involved (Stein, Remillard & Smith, 2007). Kilpatrick et al. (2001) adopt a composite and comprehensive view of successful learning which they term Mathematical Proficiency (MP). This notion was formulated on the basis of an extensive review of various dimensions of teaching mathematics in the USA. Kilpatrick et al. (2001, p. 380) propose a teaching framework that embraces five interwoven and interdependent strands of proficiency. They are:

1. conceptual understanding of the core knowledge required in the practice of teaching;
2. procedural fluency in carrying out basic instructional routines;
3. strategic competence in planning effective instruction and solving problems that arise during instruction;
4. adaptive reasoning in justifying and explaining one"s instructional practices and in reflecting on those practices so as to improve them; and
5. a productive disposition towards mathematics, teaching, learning and the improvement of practice.

1.6 RATIONALE FOR THE STUDY

Before I became a principal in 1993, I was a teacher with a passion for teaching mathematics to students ranging from six to nine years old in the Foundation Phase of schooling. Once charged with the responsibility of managing the curriculum as principal of a preparatory school, I asked myself the question: What can teachers in a South African school do in the Foundation Phase to improve the teaching and learning of mathematics?

I was concerned that many teachers in the Foundation Phase did not enjoy mathematics and seemed to lack confidence in teaching mathematics. Some teachers made me aware that they had chosen the Foundation Phase as a preferred phase for teaching because either they had not done mathematics to the Senior Certificate level of schooling, or they were just not comfortable with teaching mathematics beyond the Primary level. Yet all of these teachers indicated a strong desire to be in education and to make a difference by ensuring the successful learning of their students. I soon realised that if I wanted to learn more about mathematics education and come to an understanding of how teachers need support in the classroom, as a leader of teachers I needed to read more and learn from what the experts in the field of mathematics were saying. I was thus very excited to oversee the introduction of the SMC at my school while concurrently embarking upon a research journey to find out how to improve the teaching and learning of mathematics.

1.7 THE RESEARCH SITE

There are currently two schools implementing the SMC in the Eastern Cape and I have identified both as important for this research. These schools differ in that one is a private co-educational primary school, and the other a public (former model C) school for girls. The group of teachers selected for study are drawn from the Foundation Phase at these two schools. All staff were initially informed of the research study and invited to participate. I discussed the nature and purpose of my research and the data required from each individual teacher. The group consisted of six out of a possible twenty-four Foundation Phase teachers at the two schools. The selection was based on voluntary participation and a willingness on the part of the teachers to share their experiences within a group. I was aware that the input of these teachers could play a pivotal role during the piloting of the SMC during 2010 and 2011.

1.8 RESEARCH METHODOLOGY

This study is located in an interpretive paradigm and is interactional, interpretive and qualitative in nature (Terre Blanche & Durrheim, 2006). The interpretive paradigm is characterised by a concern for the individual (Cohen, Manion, & Morrison, 2008. p. 21), in this case, the teacher, and a desire to understand the subjective world of her experience. “Teaching for understanding” is based on the principles of constructivism; in order for new knowledge about teaching to be linked to past knowledge, reflection must take place (Goodell, 2000). The ontological framing and the epistemological principles that underpin this research study are seated within a social constructivist framework.

Within this paradigm, my case study affords me, as a researcher, the opportunity to portray, analyse and interpret the uniqueness of real teachers within local situations (Cohen et al., 2008, p. 85). As this is a case study (Cohen et al., 2008, p. 255), the focus is on a single group of teachers and how the introduction of the SMC has impacted on their teaching practice as individuals.

Various research instruments were used in four stages of the process:

Stage 1: Initial workshops and distribution of journals;

Stage 2: Questionnaire and semi-structured individual interviews;

Stage 3: Focus group discourse and observations based on video recordings of class lessons;

Stage 4: Individual presentations from Teachers A – F.

1.9 OVERVIEW OF THE STUDY

This study consists of five chapters. In Chapter 1 I briefly introduce the study, identifying the research goal and context of the study. I also describe the rationale for carrying out the study, the research site and the methodology chosen.

In Chapter 2, I present an overview of all the literature which I believe to be of relevance to this study. The major considerations for this chapter were

- The Singapore Mathematics Curriculum and its key features;
- Teacher Practice and teaching for mathematical proficiency;
- The teachers‟ knowledge base for teaching mathematics and their beliefs and attitudes;
- Observations from other studies around the world.

In Chapter 3 the research methodology used in my study is presented. Various instruments were used in the four stages of the research process, and these are introduced as each stage of the process is described.

In Chapter 4, the findings, i.e. the teachers‟ experiences, perceptions and reflections are presented and discussed.

Chapter 5 concludes the study with a summary of its findings. The potential value of the research is indicated and its limitations are acknowledged. Recommendations are made for further research in the field.

CHAPTER TWO
LITERATURE REVIEW

> After all, it is teachers who determine how the innovations envisioned by reformers and curriculum designers become implemented in mathematics classrooms.
>
> Cooney (1988)

2.1 INTRODUCTION

In this chapter I review the literature that informed my investigation. I discuss the curriculum features of the Singapore Mathematics Curriculum (SMC) and the role of a curriculum in mathematics education, most especially its influence on teacher practice. The current situation of the mathematics curriculum in South Africa is reviewed with respect to elements relevant to the focus of the study.

My discussion of the literature is grounded in the notion of teaching for mathematical proficiency as articulated by Kilpatrick et al. (2001). Initially, I sourced literature that focused on teaching and possible strategies for improving teachers‟ effectiveness in the classroom. I then made use of Kilpatrick et al.‟s (2001) framework for teaching for mathematical proficiency as a conceptual lens to analyse teaching practice in the classroom.

I also present an overview of literature regarding teacher practice which canvasses the three kinds of knowledge required for teaching mathematics successfully. The three kinds of knowledge are mathematical knowledge, the knowledge of students and the knowledge of how to teach for mathematical proficiency. I focus in part on literature pertaining to the beliefs and attitudes of teachers. I then briefly review some studies from abroad reporting on the implementation of the SMC in schools. The major elements that frame this literature review are illustrated in Figure 2.1:

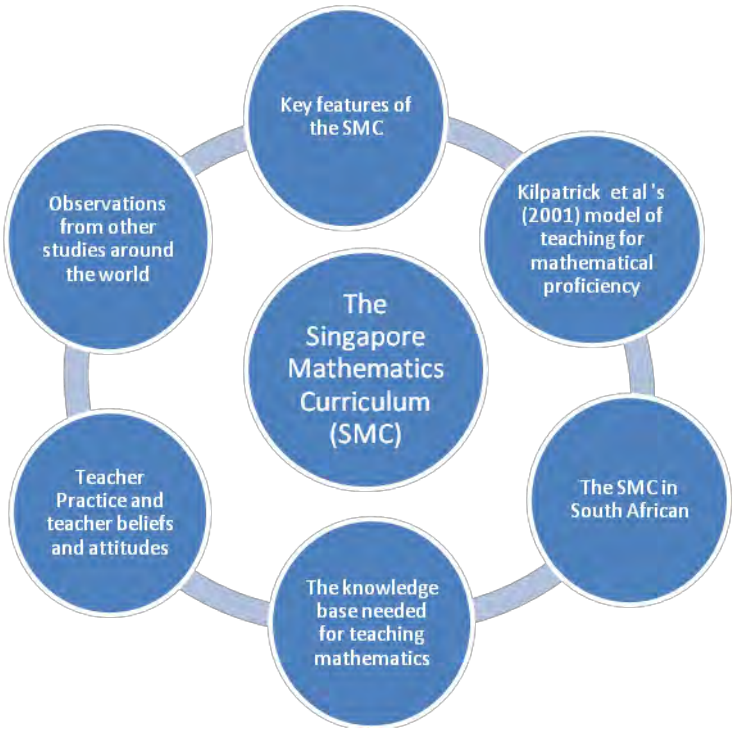


Figure 2.1: The SMC in SA schools

2.2 THE CHOICE OF THE SINGAPORE MATHEMATICS CURRICULUM

In considering a response to the challenges of improving mathematics performance in the school where I am the principal, I travelled to the US and Singapore to explore alternate curricula. My focus and intention was to investigate how to improve number sense amongst teachers and students and develop greater understanding of numeracy in the classroom.

South Africa is one of approximately twenty-five countries around the world where the SMC curriculum is currently being implemented (Marshall Cavendish, 2009). I was drawn to looking at this particular curriculum and its core components when comparing global trends in mathematics education. I reviewed various reports on the use of the SMC, where children were described as not only making sense of numbers and patterns in numbers, but also discovering the fascination and enjoyment of mathematics. Teachers using the method were reporting on various strategies their students were using in mathematics, stating that the children were engaging with challenging problem solving and having fun doing mathematics. The SMC curriculum gives clear guidelines and explanations regarding how to develop students‟ understanding of fundamental mathematics concepts and proficiency in solving basic mathematical word problems. The SMC curriculum also indicated that

more challenging and non-routine tasks, such as open-ended problems, were included in its curriculum (Singapore. MOE, 2000a).

All this encouraged me to consider the *role of the teacher* in using this approach to learning and teaching. Recording the experiences of teachers and delving into the potential influence that a foreign curriculum might have on current teaching practice became a central focus of my investigation.

2.2.1 Historical background to the curriculum in Singapore

Singapore was a British colony from 1826, attaining self-governance in 1950. It became an independent nation in 1965. Today Singapore is a prosperous, multicultural, multilingual nation of 4.5 million people.

During colonial rule, English schools primarily served the purpose of training civil servants for the British government in Singapore (Yee & Lianghuo, 2002). Many of the schools were missionary schools, whilst the Chinese community funded its own schools. A legacy that remains is that some of the top schools in the urban areas are still exclusively for boys or for girls only. The Singapore Government acknowledges human resources as its most important resource, and investing in the education system of the country takes priority.

The Singapore education system‟s approach to mathematics education has its roots in the mathematics curricula developed in the former Soviet Union, whose goal was a high achievement rate amongst scholars in mathematics and science. The Soviets brought together mathematicians and developmental psychologists to devise the best way to teach mathematics to children (Milgram, 2008). The Soviet curriculum was adopted by China in the mid-1950s and it later made its way to Singapore, where it was rewritten and refined. The Singapore mathematics syllabus for both primary and secondary levels of schooling emphasises the development of students‟ ability to solve problems (Singapore. MOE, 2000a, 2000b). This is fundamental to Singaporean mathematics education programmes.

In 2003 the Trends in Mathematics and Science Study (TIMSS), a widely accepted comparison of global mathematics skills, revealed that at both the fourth and eighth grade levels, Singapore was the top country, with their students attaining significantly higher scores in mathematics than the rest of the participating countries (Reddy, 2006). The TIMSS also investigated the match between test items and the school curricula to explain the comparative results in different content areas. It is meaningful to

note this alignment between what is taught within a curriculum and what is assessed as pertinent to the TIMSS. The intended and the implemented curriculum in Singapore is particularly closely aligned (Kaur, 2000). The TIMSS results show that Singapore has been a top performing nation in mathematics and science over the past fifteen years (Gonzales, Williams, Jocelyn, Roey, Kastberg & Brenwald, 2008). Singapore students‟ superior mathematics achievement could be the result of the nation‟s unique approach to teaching the subject, using a pedagogy that is quite distinct from programmes typically found in the Western world (Ginsburg, Leiwand & Decker, 2009). The widespread use of the instructional SMC mathematics texts "My Pals Are Here"[3] suggested that part of the success might be attributable to the use of this curriculum (Kheong, Ramakrishnan & Wah, 2007a).

2.2.2 Key Features of the Singapore Mathematics Curriculum (SMC)

The SMC approach to the learning and teaching of mathematics has certain key characteristics and the curriculum framework presents distinctive features, as follows (Singapore. MOE, 2009).

Curriculum Framework

The curriculum framework has continually been changed and developed as a result of curriculum review (Singapore. MOE, 2003). Five components remain constant, however, as illustrated in Figure 2.2.

[3] "My pals are here" is the title of the series of SMC resource books published by Marshall Cavendish, Singapore.

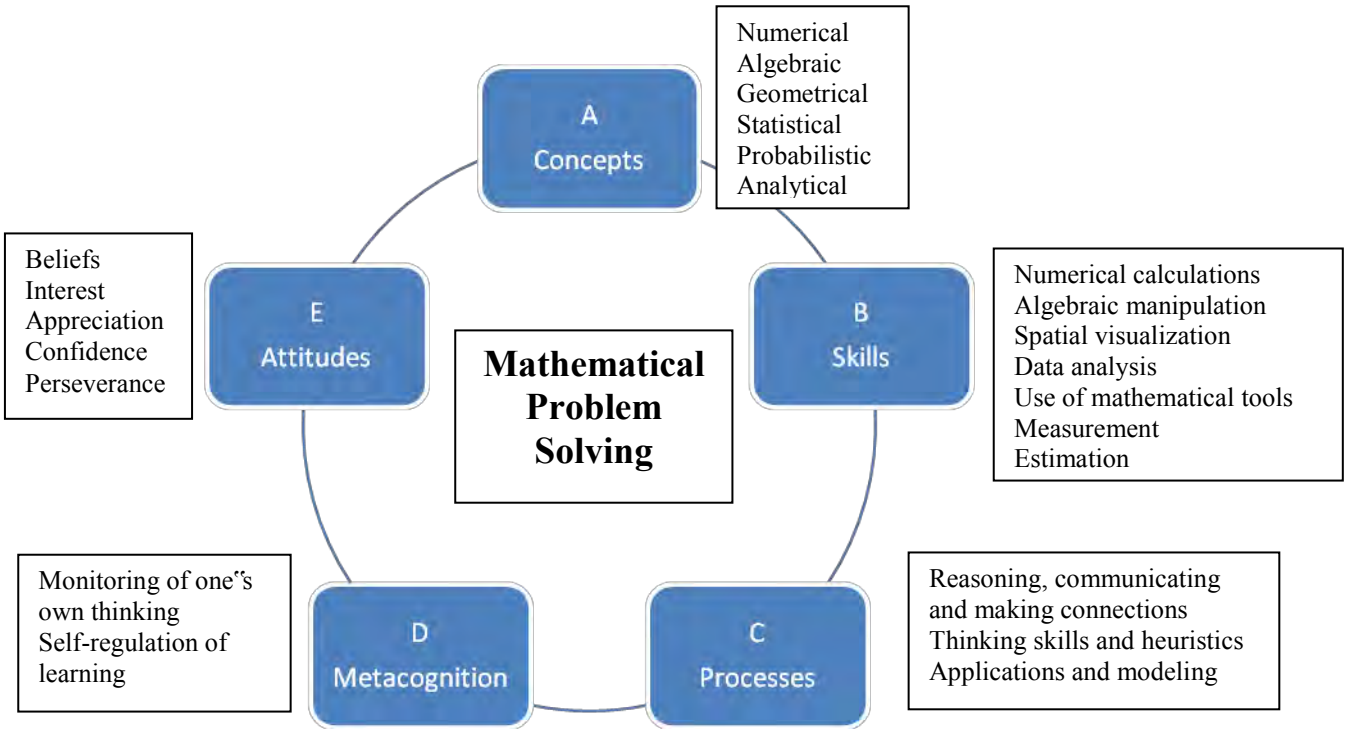


Figure 2.2: The Singapore Mathematics Curriculum Framework (MOE. 2003)

- The first component is that of mathematical *concepts*. This covers all numerical, algebraic, geometrical, statistical, probabilistic and analytical concepts. Students should be able to explore and develop mathematical ideas and concepts in depth so that they come to see mathematics as "an integrated whole and not merely isolated pieces of knowledge" (Singapore. MOE, 2009, p. 5). This requires a variety of teaching and learning experiences as set out in the SMC. It is hoped that, in developing an understanding of number concepts, students will come to make sense of various mathematical concepts. Understanding refers to the individual's ability to make sense of basic mathematical concepts and ideas and use them in a range of situations.
- The second component is the development of mathematical *skills*, including procedural skills for numerical calculations. It includes skills for algebraic manipulation, spatial visualisation, data analysis and the use of mathematical tools. Being able to calculate relies on both the understanding and the carrying out of mathematical procedures. Whilst the development of various mathematics skills is essential, it is important to incorporate thinking skills in the development of skills proficiencies. The SMC guards against over-emphasising procedural skills without a concomitant understanding of the underlying principles (Singapore. MOE, 2009). Thus the SMC insists on the importance of both components of the curriculum: the balance between them is dealt with in depth later in this chapter, at 2.3.4.
- The processes component of the SMC refers to the knowledge skills or process skills involved in the process of acquiring and applying mathematical knowledge. Children need to reflect on

how they solve a problem, and by thinking about what they do, enable their actions to contribute to greater conceptual knowledge: they come to reason and see mathematics as sensible. The various thinking skills in the SMC are referred to as heuristics. These are different strategies that students use to help them solve problems. They are dealt with in greater detail in table 2.1.

- The capacity for logical thought, explanation and being able to think about and justify what one does in mathematics is a fourth component termed *metacognition* in the SMC. Reasoning is central to being able to formulate, represent or solve mathematical problems. As one thinks about what one is doing, one is monitoring one‟s own thinking.
- The fifth component deals with the affective aspects of learning mathematics and how one engages with a problem in order to solve it. This component deals with the development of a positive *attitude* towards mathematics, in terms of which one‟s beliefs about mathematics and the usefulness thereof are important. An interest in and enjoyment of mathematics is deemed to be as important as the confidence of a student doing mathematics. *Perseverance* was added to the SMC in 2000 in the light of non-routine problem solving and open-ended questions, which call for students to investigate and find solutions using the heuristics mentioned in the processes (Singapore. MOE, 2009).

The above components of "effective mathematics programmes are applicable to all levels and grades of schooling from the primary to the advanced levels" within the SMC (Singapore. MOE, 2000a). These principles establish the direction for the teaching, learning and assessment of mathematics. The mathematical concepts covered should explore and develop the mathematical ideas in depth. The concepts should be viewed as an integrated and connected package, not as isolated pieces of knowledge. Although the SMC places importance on students becoming competent in the various mathematical skills, an over-emphasis on procedural skills without an understanding of the underlying mathematical principles should be avoided. Within the curriculum, the concepts and skills are carefully and explicitly set out for each grade (Singapore. MOE, 2009; see 2.3.4, below).

Problem solving

Following the movement towards emphasising problem solving in the world of mathematics in the 1980s, the problem-solving approach is central to the Singapore primary mathematics curriculum

(Wong, 1991).[4] The Mathematics Framework, which was incorporated into school mathematics in 1992, is centred on the aim of developing students‟ mathematical abilities and mathematical problem-solving skills (MOE, Singapore, 2000a).

Heuristics

There are eleven heuristics presented in the mathematics syllabus at the primary level (Singapore. MOE, 2000a). Heuristics, in this context, are the different strategies or thinking skills which students use to approach a problem. The inclusion of a range of heuristics within the curriculum serves to enhance one‟s thinking ability and help students formulate or represent a problem when trying to solve it. Bar modelling is a specific variant of the common "Draw a model/diagram", and is the first heuristic listed in the syllabus (Singapore. MOE, 2000a).

Within the primary school curriculum, the model method is the most important heuristic, although there are a further ten heuristics referred to (Singapore. MOE, 2000a). The eleven heuristics are listed below in Table 2.1.

Act it out	This heuristic is particularly useful for the younger students who enact the situation to realise the solution.
Eliminate options	This strategy can be applied when some of the options given are not the answer and this allows students to focus on what may be possible.
Guess and check	By using the trial and error approach, it is very useful for simple problems and systematic listings can help narrow down the options to make a correct guess in the shortest time possible.
Look for patterns	A strategy so useful in searching for patterns involves an active search where there is a sequence of numbers or figures and where generalisation is needed. In this way the information can be expressed or viewed in an organised manner.
Make suppositions	By using simulated numbers one is able to make the problem solving real.
The Model Drawing	This bar modelling tool allows students to represent problems symbolically. They draw a bar to represent a number. This drawing technique is a special variant of the strategy termed "model method".
Restate the obvious in another way	This approach helps to clarify and organise one‟s thoughts.
Simplify the problem	When one changes the form in which a problem is posed, it may become more understandable to separate the problem into sub-sections to be solved individually in sequence.
Use the before and after concept	When listing the information given before an action and the information given after an action, the student is able to compare the information to

[4] Khoon Yoong Wong is an Associate Professor at the National Institute of Education (NIE) in Singapore in the Mathematics and Mathematics Education Department.

	find the unknown.
Tabulate or make a systematic list	If the information is organised or generated into a systematic manner and used in conjunction with the "look for patterns" by accounting for all possibilities in a systematic way, it is a further strategy.
Work backwards	When the result or whole part has been given, it is often applied to real life problems and can assist with a solution.

Table 2.1: The eleven heuristics covered in primary mathematics in the SMC (Singapore. MOE, 2000a).

The Model Method

The Model Method (Singapore. MOE, 2009) is a distinctive feature of the SMC. The use of a model drawing is proposed as a pedagogical strategy to develop a student‟s proficiency in solving basic mathematics word problems. It is particularly useful for problems that involve comparisons, part-whole calculations, ratio and proportion. Referred to as the "Singapore Model" (Singapore. MOE, 2009), it can be used in different ways to represent different mathematical ideas. The model is associated with the construction or drawing of a pictorial bar or rectangular shapes to represent known and unknown quantities (Kho, 1987). The students are taught to represent a problem in this visual form. This can be of particular benefit in helping students make progress with unfamiliar or difficult problem solving.

Here are some examples of the use of the model method:

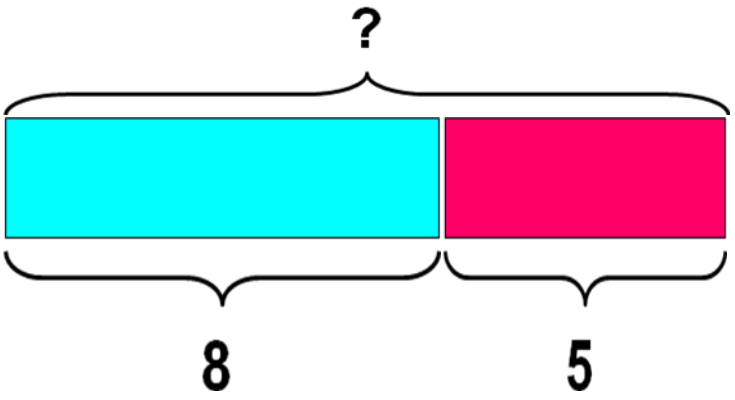
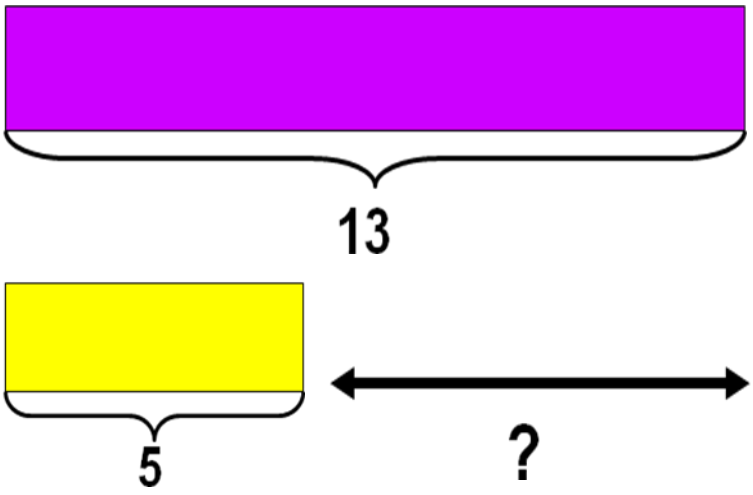


Figure 2.3: The part – part whole model drawing

PROBLEM: The part-part whole model.
Chloe collects eight shells on the beach. Her mother finds another five and gives them to Chloe. How many shells does Chloe have altogether?
8 + 5 = 13
Chloe collects 13 shells altogether.

In Figure 2.3 the drawing of rectangular shaped bars to represent each number within the problem posed, shows the whole unknown number when the two parts are given. Students may first make use

of concrete objects to make sense of the part-whole concept before progressing to the drawing of the model as a pictorial representation.



PROBLEM: The comparison model.

Sihle has 13 marbles. Her brother has 5 marbles. How many more marbles does Sihle have?

13 – 5 = 8

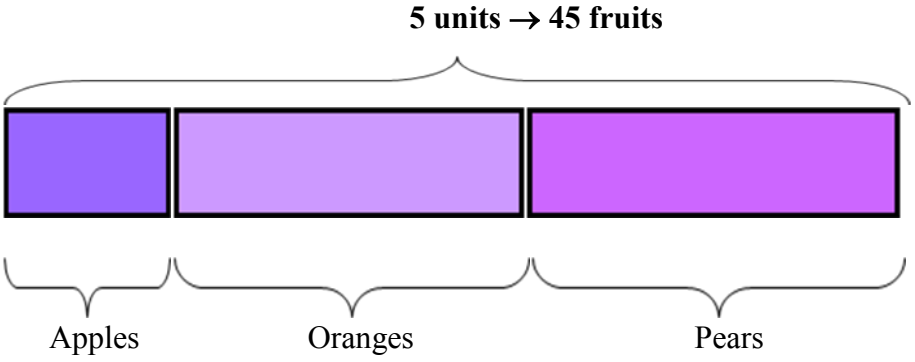
Sihle has eight more marbles.

(Alternate solution: 5 + 8 = 13)

Figure 2.4 The comparison model where the whole is given and a part is unknown.

In Figure 2.4 the drawing of rectangular shaped bars represents, first, the whole known number. When only one of the two parts is given, the missing number is the difference as indicated. Students may first make use of concrete objects to start making sense of the whole concept before progressing to the drawing of the model as a pictorial representation. As illustrated in Figure 2.4, the progression of drawings shows when a problem involves two separate bars, using a part as a comparison model of the given whole.

To further illustrate the method, the following problem is posed, where fractions are viewed as parts of a whole. Figure 2.5: Model drawing of fractions as part of a whole.



PROBLEM

There are 45 fruits in a crate. 2/5 of them are oranges, 1/5 of them are apples and the rest are pears. How many pears are there?

SOLUTION

There are 18 pears

In Figure 2.5 the parts are represented proportionally to demonstrate how two parts can be drawn as a single bar double the size of the original part. This approach to problem solving grants the students opportunities to construct their own models in written form. It can be developed into a more complex model as the students engage with more challenging problem solving. The "model method" receives much attention in the Singapore syllabus, in research, and in classroom instruction (Wong, 1991).

Manipulatives and resources

The SMC advocates the use of a wide range of resources to explore number concepts, including "hands-on" manipulatives and practical mathematical apparatus. According to Van de Walle (2004), the term manipulative is applied to any object, picture or drawing that represents a mathematical concept or onto which the relationship for that concept can be imposed. Manipulatives are physical objects specifically designed to foster learning. The "hands-on" learning approach proposes that students be actively engaged when doing mathematics. It calls for the use of concrete apparatus when any new concept or learning idea occurs.

The knowledge children gain in the various subjects in a school or other educational environment is described by a leading cognitive theorist, Bruner (1966), in terms of *three stages of acquiring knowledge*. He suggests that there are three stages in the process of transforming experience into models of the world, as follows:

1. the *enactive stage* (through actions and doing), proceeding to
2. the *iconic stage*, where actions are represented as images (pictorial representation in the mind or representative images on paper), followed by
3. the *symbolic stage*, where through language the students come to understand the symbolic form of ideas or facts.

In the SMC, these stages are referred to as the three-step, Concrete-Pictorial-Abstract approach to teaching and learning mathematics. The SMC calls for students to be provided with a variety of concrete manipulatives to support this three-step process.

Other independent research supports the idea that mathematics instruction and student mathematics understanding will be more effective if manipulative materials are used (Skemp, 1987). By

manipulative materials I mean objects that a student can independently touch and move around, as opposed to watching a demonstration by a teacher. This independent manipulation assists in the meaningful experiencing of apparatus before the student proceeds to the next stage of the process, representing the solution in pictorial form. The student is then introduced to abstract thinking in mathematics. This "learner-centred" approach to learning affords students opportunities to develop conceptual understanding of numbers as they work with tangible objects. In SMC, this sequential flow of three stages of working with number is explicit and evident throughout the primary curriculum (Singapore. MOE, 2009).

A further resource in the SMC is the detailed teacher‟s manual, which provides clear schedules, instruction and guidelines. The "pedagogical content knowledge" (Shulman, 1986) is embedded in the material, through the provision of very explicit teaching steps. The students are provided with textbooks containing multi-step problems and pictorial illustrations that suggest how mathematical strategies can be used to solve problems from various different perspectives. The textbooks are supported by workbooks for consolidation in the classroom, and homework books which provide further exercises on the concepts covered at school on a daily basis. There are additional differentiated workbooks for re-teaching or enrichment. The e-learning portal is an extra resource used by School B since 2010. This is a password-accessible website with Singapore Mathematics tutorials and supplementary mathematical activities and games. It was made available to teachers and students and may be loaded on computers at home at an additional cost.

Spiral approach

Mathematics Education in Singapore regards the acquisition and application of concepts and skills as equally important (Singapore. MOE, 2009). The content is carefully planned and explicitly set for the teachers at each grade level. Mathematic content knowledge is deepened progressively through a spiral approach. The use of "*a spiral approach"* when teaching and learning mathematics is "to ensure that each topic is covered at appropriate levels in increasing depth" (Singapore. MOE, 2000a, p. 3). This is to prevent the teaching of a concept repeatedly at the same basic level across the grades, and instead of covering the same shallow concepts annually, the development of deeper insight into a concept is envisaged. Singapore‟s texts also present material in a sequence that continues to builds on prior lessons throughout the grades (Garelick, 2006). This spiral approach is also beneficial in teaching for a purpose where the fundamental concepts continue to have substantial importance in more sophisticated applications at a later stage or grade. Concepts and skills are taught to mastery before moving on to the

next level, and the next level is properly sequenced to build upon the mastered material (Garelick, 2006). Mathematics education in Singapore places importance on the acquisition and application of both mathematics concepts and skills at each specific grade level. The spiral curriculum places an emphasis on carefully planned and explicitly set tasks that will enable students to be ready for the next level of learning (Singapore. MOE, 2009).

Investigating best practices around the world inspired me to explore an alternative curriculum to enhance learning at the school where I am principal. The role of the teacher in the implementation of a new curriculum was not to be taken lightly. When the U.S. Department of Education commissioned a study in 2005 to find out why Singapore is ranked number 1 according to the TIMSS 2003 results, it concluded, in part, that "Singapore's textbooks build deep understanding of mathematical concepts through multi-step problems and concrete illustrations that demonstrate how abstract mathematical concepts are used to solve problems from different perspectives" (American Institute for Research [AIR], 2005). Talking about the SMC, Roger Howe[5] has stated: "It provides the basis for a very orderly and systematic conceptual understanding of arithmetic and mathematics" (Landsberg, 2008). The fact that Singapore retained top spot in the TIMSS global assessment in 1999 and 2003 (Reddy, 2006) added further credibility to my choice of the SMC for implementation in my school.

2.2.3 The SMC in South Africa

Attending conferences abroad allows one to glean information and elicit reports from teachers sharing best practices from their own countries. As a South African teacher attending an international conference in the United States of America,[6] I came into contact with some of the work of the NCTM. The theme of the conference was "Educating girls for a world of opportunities". Teachers from the United States also shared their interest in taking lessons from other countries, and it was suggested that I look to East Asia for ideas on how to improve mathematics education in my school. The teachers reported that "Math in Focus"[7] had been introduced into certain states in the United States. "Math in Focus" was launched in 2003, and in 2008 the state of Oregon approved the use of "Math in Focus" in all kindergarten and elementary schools, bringing the number of states adopting this curriculum to 31 out of the 50 states in the USA (Marshall Cavendish, 2009).

[5] Roger Howe is a professor of mathematics at Yale University, USA.
[6] National Coalition of Girls' Schools (NCGS) conference in Baltimore, Maryland, 2007
[7] "Math in Focus" is the USA Edition of Singapore Mathematics

In South Africa, the implementation of the SMC first occurred in Gauteng, when a private school started using the SMC curriculum in 2006. Subsequently it has been adopted by a number of private schools throughout the country. A pilot project to implement SMC in schools commenced in 2008; it is managed by ORT SA in consultation with the Gauteng Department of Education and funded by Bidvest (Jet Education Services, 2009). The aim of the project was to improve the levels of student achievement in Numeracy in the Foundation Phase in Alexandra Township, located in the Gauteng province. This project is in its third year of operation, and now incorporates six primary schools. The project commenced with the training of teachers of Grade 1 in April 2008, Grade 2 in 2009, and Grade 3 in 2010.

An opportunity to invite an experienced teacher of the SMC to present a workshop at our school arose through collaboration with teachers in Gauteng. The staff from both the schools involved in this project attended the initial training session in 2008. As principal of one of the schools, I was fortunate to have members of my governing body present at this inaugural workshop, and the SGB, in consultation with teachers on the school management team, subsequently accepted my proposal for implementing the SMC in 2009. This meant phasing in the SMC, starting with Grade R and Grade 1 teachers in the first year. Simultaneously, the local private school had also made the decision to implement the SMC. Their decision was to incorporate the SMC into all Grade 1 to Grade 3 classes simultaneously. At present these are the only schools in the Eastern Cape Province offering the SMC across the entire foundation level, and are piloting the curriculum in Grades 4 and 5, respectively, in 2011.

The implementation of the SMC involves the use of an extensive range of resource books, bearing in mind that a good textbook contains, in a single source, a comprehensive study programme for the year. It lays the curriculum out systematically, providing expositions of the concepts, definitions of the terms and symbols of the subject in question, worked examples of standard and non-standard problems, lots of graded exercises, and answers. Both national and international research has repeatedly underscored the role of the textbook as one of the most effective tools through which to deliver the curriculum and support assessment. Not only can it ensure curriculum content and assessment coverage, but it can also offer appropriate pacing and weighting of content, and assist teachers with lesson and year planning. In the light of this statement, particular attention will be given to the findings in respect of the use made by the six teachers in this study of the SMC guidelines on content, pacing and assessment.

2.2.4 The changing South African Curriculum

The context of any effort to experiment with new approaches to maths education in South Africa should take account of the historical and current context of a changing curriculum landscape in South Africa. The amended National Curriculum and Assessment Policy Statements (CAPS) in South Africa is scheduled to replace the National Curriculum Statements Grades R – 9 (2002) and will come into effect in January 2012 (South Africa, DBE, 2011). At the time of writing, two versions of the Singapore textbooks and workbooks have been aligned to the CAPS documents and have been submitted to the DBE for consideration and approval on the SA national list of approved resources.[8]

Briefly considering the history of curriculum change in our democratic country, one notes that Curriculum 2005 was implemented in South Africa in 1998 and was intended to promote the rebuilding of a fragmented society (South Africa. DOE, 2003). This curriculum proposed a change in teaching from a behaviourist approach, based on the idea of the teacher as transmitter of knowledge, to a constructivist learner-centred approach (Brodie, 2010; South Africa. DBE, 2009b), in terms of which the teacher becomes a facilitator of knowledge. Students‟ interaction and learning experiences would depend on guidance from teachers, and teachers‟ key role would be to lead students in their own discovery and understanding of number (Driver & Oldham, 1986). Obviously, this required a change in the role and function of teachers, from being the transmitter of knowledge providing information and facts to students, to guiding and helping students in their conceptual organisation of certain areas of experience (South Africa. DOE, 1997). From the outset, the South African approach to Curriculum 2005, an outcomes-based curriculum, has been problematic (Brodie, 1997). Whilst the rationale and philosophy behind the post-apartheid ideals are commendable, there have been problems. The implementation of a new curriculum within the foundation phase of schooling since 1998 has had numerous shortcomings. In 2003 the Trends in Mathematics and Science Study (TIMSS), a widely accepted comparison of global math skills, revealed that at the eighth grade level, South African was ranked 46 out of 46 participating countries (Reddy, 2006).

The implementation of the Revised National Curriculum Statements (RNCS) in January 2004 was an attempt to re-focus and improve the new curriculum. Mathematics Education is regarded as a vehicle for social change within our country, yet the lack of alliance of the SA curriculum with actual practice is problematic. In 2007, the National Policy on Assessment and Qualifications for schools in the

[8] *Discover Maths* is the South African version aligned to CAPS published by Marshall Cavendish awaiting approval on the South African National Catalogue list.

General Education and Training (GET) band[9] was introduced. Together the revised national curriculum statements and the policy document on assessment provide the basis from which schools and teachers are expected to plan, teach and assess their students in the GET band (South Africa. DBE, 2009c). The Foundation Phase of schooling in South Africa falls within the GET band.

The current Minister of Basic Education, acknowledging the issues and challenges reported in October 2009, has called for a third change, a second overhauling of the curriculum (South Africa, DOE, 2009b). The Department of Education in 2010 released draft copies of the National Curriculum and Assessment Policy Statements (CAPS) documents within the mathematics curriculum in Foundation Phase (SA, DBE, 2010). The current South African Curriculum now privileges what are regarded as knowledge, skills and values worth learning. Its aim is "to promote the idea of grounding knowledge in local contexts, while being sensitive to global imperatives" (South Africa. DOE, CAPS, 2011). Two of the aims of the SA curriculum are to produce learners who are able to:

- Identify and solve problems and make decisions using critical and creative thinking
- Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.

The prescribed instructional time for Mathematics in the Foundation Phase in SA is seven hours a week, and there are five core areas of mathematical content to be covered. The weighting of mathematics content areas serves to guide the amount of time needed to address each content area. The weighting also provides guidance on the spread of the content in the examinations. In the foundation phase all assessment is continuous assessment. The Eastern Cape provides two common tests for Grade 3 in June and November and the weighting is taken into consideration in these papers. The specific content headings are then listed according to grades and specific terms of the year in which they are to be introduced (South Africa, DOE, CAPS, 2011).

2.3 TEACHER PRACTICE

Kilpatrick et al. (2001) have much to say about teaching practice for mathematical proficiency that appears to be in line with the principles of the SMC. Their work therefore offers a very appropriate framework for doing the following with regard to this study:

1) creating a framework for analysing the SMC in respect of teaching for mathematical proficiency;

2) providing a framework for my analysis of the sample teacher practices, and

[9] The General Education and Training (GET) band refers to Grade R to Grade 9 learners in South Africa.

3) providing guidelines for the participating teachers seeking opportunities for improvement.

The model of teaching for mathematical proficiency offered me an integrated view of what are generally regarded as the major elements of successful mathematics teaching and learning, though Kilpatrick et al. (2001, p. 116) acknowledge that "no term captures completely all aspects of expertise, competence, knowledge and facility in mathematics". "Mathematical proficiency" is the term they associate with what they believe is necessary for anyone to learn mathematics successfully.

2.3.1 Teaching for mathematical proficiency

Kilpatrick et al."s (2001) five strands of teaching for mathematical proficiency featured prominently in the Rhodes University M.Ed. (Mathematics) course work. It was surprising to discover that the SMC is grounded in the very same five strands (SMC documentation in fact explicitly acknowledges and embraces the work done by Kilpatrick et al., 2001, and the NCTM, 2000a). This relationship will be explored more fully in section 2.3.3 of this review.

The extensive research done by Kilpatrick et al. (2001) relates to the notion of Mathematics Proficiency (MP) and involves a composite and comprehensive view of successful learning. According to Kilpatrick et al. (2001, p. 369), "proficiency in teaching is also related to effectiveness, consistently helping students to learn worthwhile mathematical content". Kilpatrick et al. (2001) also state that the successful implementation of a mathematics curriculum is directly influenced by the proficient teaching practice of the teachers implementing the curriculum. They present a model of what teaching for mathematics proficiency comprises, a model was formulated on the basis of an extensive review of various dimensions of teaching mathematics in the USA (Kilpatrick et al., 2001).

2.3.2 The five strands of teaching for mathematical proficiency

What does it mean to be successful in mathematics? According to Kilpatrick et al. (2001, p. 380), the five interwoven and interdependent strands of mathematical proficiency encapsulate what it means to successfully learn mathematics. Their emphasis rests on what this means for understanding mathematics as well as on what this means for teaching mathematics. The five strands used to describe mathematical proficiency, as illustrated in Figure 2.6, are:

- **conceptual understanding:** the understanding of the core knowledge of mathematics concepts required in the teaching of mathematics. It is the

"integrated and functional grasp of mathematical ideas" (Kilpatrick et al., 2001, p. 118), and includes the use of different teaching strategies (pedagogical knowledge) in the practice of effective teaching and learning.

- **procedural fluency:** the ability to carry out basic instructional routines or procedures accurately and efficiently; this includes knowing when and how to use procedures and skills appropriately in any instructional practice, referring to the classroom management routines;
- **strategic competence:** the ability to come up with effective planning and instruction for solving problems that arise during instruction and the decisions the teacher makes when planning what when and how to teach as well as how to adapt to the needs of the students;
- **adaptive reasoning:** to be able to think reasonably and logically about a problem, justifying and explaining one‟s instructional practices, and in reflecting on those practices so as to improve them, being able to analyse difficulties encountered noting students responses; and a
- **productive disposition:** a notion of the usefulness and worth of mathematics, making sense of one‟s teaching and the connection between mathematics and students‟ thinking and learning; it is ultimately about the improvement of practice through the affective aspect of mathematical learning.

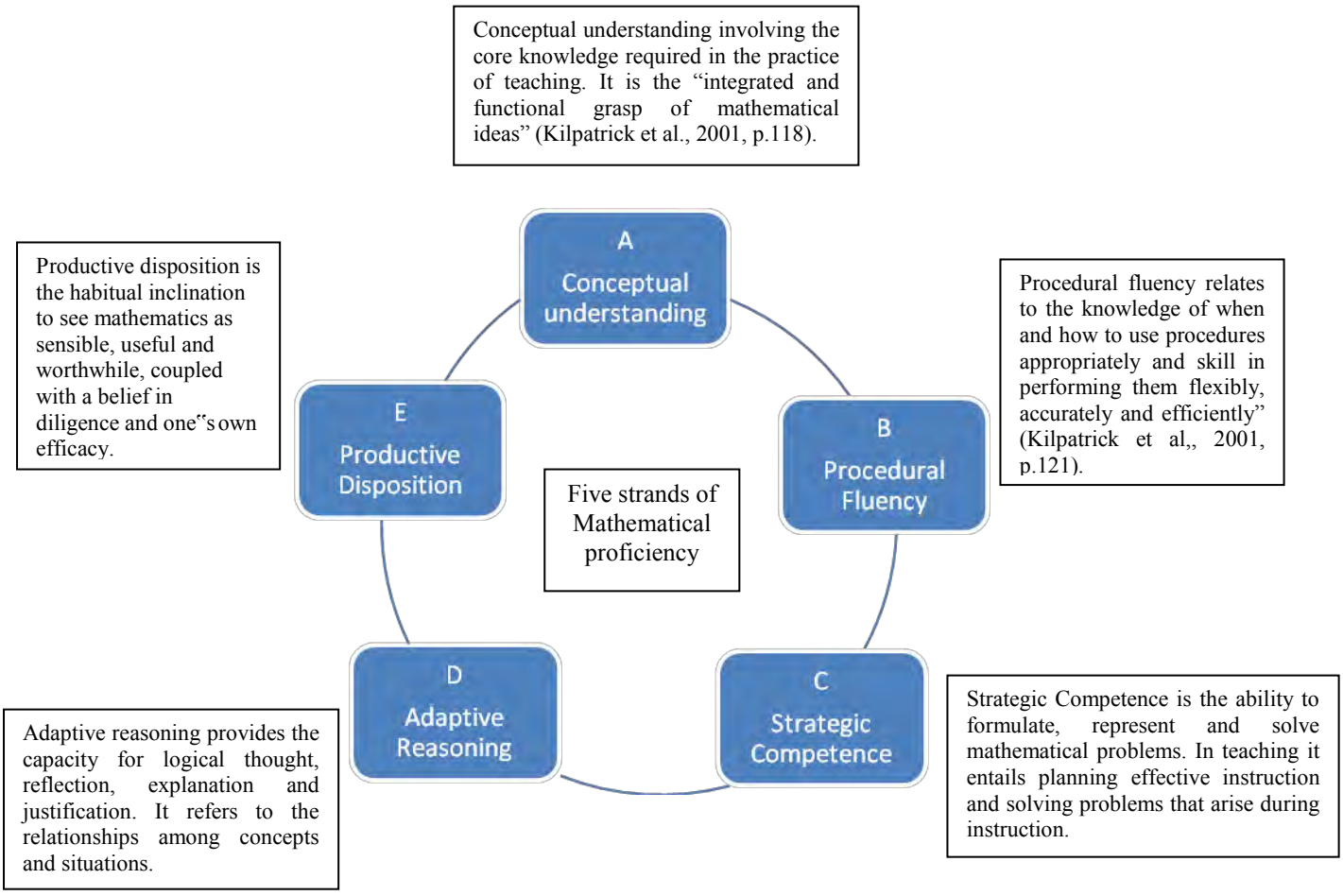


Figure 2.6 The five strands of teaching for mathematical proficiency

2.3.3 Kilpatrick and the SMC: The match of concepts

As indicated above, one of my pleasant surprises in reviewing the literature was discovering how closely the SMC framework (Singapore. MOE, 2003) was aligned with Kilpatrick's concept of Mathematical Proficiency. This was of particular significance to my study. Table 2.2 shows the close alignment of the five strands of Mathematical Proficiency to the five components of the Singapore Mathematics Framework.

Singapore Mathematics Framework	Five strands of Mathematical Proficiency (MP)
Concepts – all mathematical concepts including numerical, algebraic, geometrical, statistical, probabilistic and analytical concepts.	Conceptual understanding – the comprehension of mathematical concepts, operations and relations
Skills – the procedural skills for numerical calculation, algebraic manipulation, spatial visualisation, data analysis, measurement, use of	Procedural fluency – skills in carrying out procedures flexibly, accurately, efficiently and appropriately.

mathematical tools and estimation.	
Processes refer to the knowledge skills or process skills involved in the process of acquiring and applying mathematical knowledge • reasoning, communication and connections • thinking skills and heuristics • applications and modelling	Strategic competence – the ability to formulate, represent and solve mathematical problems.
Metacognition or "thinking about thinking" refers to the awareness and ability to control ones thinking processes • monitoring one"s own thinking • self-regulation of learning	Adaptive reasoning – the capacity for logical thought, reflection, explanation and justification.
Attitudes refer to the affective aspects of mathematical learning such as • beliefs about mathematics and its usefulness • interest and enjoyment in learning • appreciation and the beauty and power of mathematics • perseverance in solving a problem	Productive disposition – the habitual inclination to see mathematics as sensible, useful and worthwhile, coupled with a belief in diligence and one"s own efficacy.
Singapore. MOE, 2009: Curriculum Planning & Development	USA, NCTM, 2000: National Research Council: "*Adding it up"*

TABLE 2:2 A comparative summary between the SMC framework and the (Kilpatrick et al., 2001) framework of mathematical proficiency.

Discovering that the two frameworks were so closely aligned afforded me the ideal opportunity to view teacher practice through the lens of Kilpatrick et al."s (2001) model and to closely interrogate the SMC from the perspective of the five strands of teaching for mathematical proficiency.

2.3.4 The balance between conceptual knowledge and procedural fluency

The need for the acquisition and application of both mathematical concepts (conceptual knowledge) and mathematical skills (procedural fluency) within the mathematics education programme makes it important to achieve the right balance between conceptual knowledge and procedural knowledge. At the foundation phase level of teaching and learning it is hard to separate these two component parts of mathematics education. Nevertheless, the development of both types of knowledge is crucial within the foundation phase or early learning of mathematics and needs to concur currently (Rittle-Johnson & Koedinger, 2009). According to Kilpatrick et al. (2001), both strands are of equal importance and are interdependent and interwoven. The teacher‟s role is therefore to develop the strands simultaneously and, by teaching towards their integration, promote the development of mathematical proficiency in students. From the outset, the SMC makes reference to the importance of both of these strands in the lesson design, stating the number concepts needing to be taught and understood.

A key question is to ascertain whether the conceptual understanding of number sense is being constructed by students themselves within the classroom. Misconceptions may arise from structures that take an understanding from one domain and over-generalise it to another. This may happen when teaching practice emphasises procedures and instructions over understanding (Schoenfeld, 1992). As teachers come to reflect on what they are teaching, it is to be hoped that they will themselves develop more efficient ways of connecting procedural and conceptual knowledge. A deficient knowledge base, or a lack of conceptual knowledge, will impede students‟ ability to link concepts and procedures.

2.3.5 The instructional triangle

All of the strands for MP are dialectically linked, as emphasised in Kilpatrick‟s instructional triangle (depicted in Figure 2.7), where teachers and students are seen to interact with one other and the subject content.

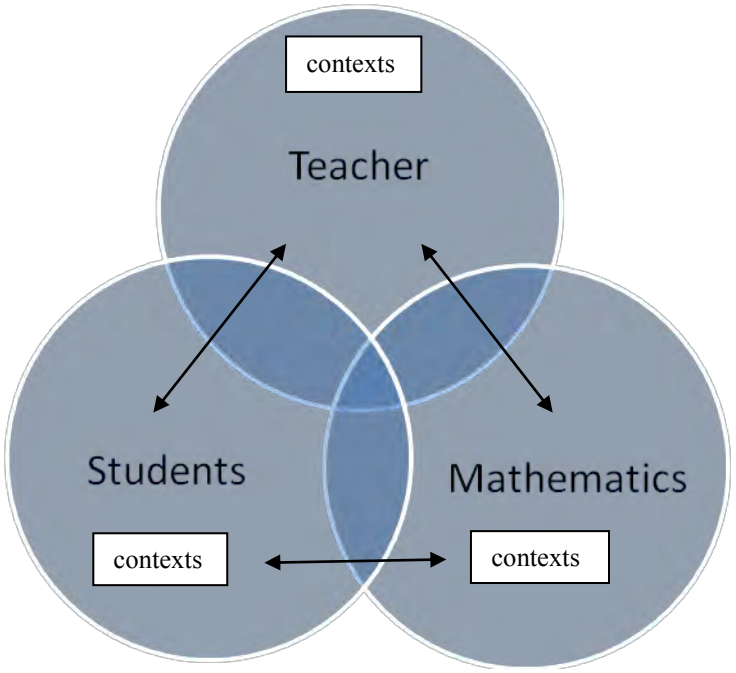


Figure 2.7 The instructional triangle: The product of interaction among teachers, students and mathematics in contexts. Source as cited in Kilpatrick et al. (2001, p. 314)

The SMC also calls for interaction based on an active engagement with mathematics among students and teachers, reiterating the importance of the instructional triangle as described by Kilpatrick et al. (2001). What is stated in the SMC manual needs to be interpreted and delivered as mathematics instruction. Understanding how children learn and make sense of the world in which they operate requires a change of focus in learning and teaching (Prawat, 1992, p. 357). This change in focus lies at the heart of this study.

2.3.6 The knowledge base for teaching mathematics

According to Kilpatrick et al. (2001) there are three kinds of knowledge crucial for teaching school mathematics. These are mathematical knowledge, the knowledge of students, and the knowledge of how to teach for mathematical proficiency. Kilpatrick et al. (2001, p. 370) observe that teaching is about the interaction between the mathematics, the students and the teacher in the daily teaching and learning of mathematics.

Mathematical Knowledge

The knowledge of mathematics includes knowing mathematical facts, concepts, procedures and the relationships among them. Kilpatrick et al. (2001) highlight the importance of mathematics knowledge specific to the teaching of mathematics and repeatedly insist on the need for teachers to gain this knowledge. In order to teach well, according to Shulman (1986), teachers need to develop a deep, interconnected understanding of the mathematical content they are expected to teach as they need to know more mathematics than their students. This calls for teachers to follow an approach based on a sound knowledge of mathematics and understanding of the curriculum framework. Knowledge of the curriculum is an area in which Shulman (1986) feels strongly that teachers need to pay more attention. The teacher‟s role is pivotal in the delivery of a curriculum. It is up to the teacher to determine how to make appropriate adaptations to accommodate the curriculum in teaching and learning within the social organisation of the individual class. The organisation of the school can also influence the curriculum transformation process (Stein et al., 2007). How the teacher interprets the curriculum materials and what happens when the curriculum tasks are introduced in the class will bring about different outcomes. Since no curriculum is self-enacting, it is a challenge for teachers to act upon a curriculum in a way that will lead to improvement in student learning. I regard teacher education as a professional continuum and concur with the NCTM (2000) that it is a career-long process. Learning is for life, and "teachers need a basis for ongoing learning. They need to be able to adapt to new curriculum frameworks, new materials, advances in technology, and advances in research on student thinking and teaching practice. They have to learn how to learn, whether they are learning about mathematics, students, or teaching" (Kilpatrick et al., p. 385).

The knowledge of students

Kilpatrick et al. (2001) state that teaching for mathematical proficiency requires that teachers pay careful attention to the variety of possible student responses during the course of a specific lesson, and to the question of how to react to those responses in order to further the development of students‟ knowledge. This is the knowledge that teachers need to have of their learners and how various ideas develop in students over time. This includes knowing the child personally, and understanding his or her background, how s/he thinks and how s/he learns. Observing the different learning styles that students may prefer and having a general knowledge of students of a given age are important. This includes being familiar with the typical conceptions and misconceptions that students develop and

hence recognising their prior knowledge. Errors and misconceptions are a normal part of learning, and teachers should work with them to instil correct mathematical ideas (Chazman & Ball, 1999).

Knowledge of students is seen as one of the key areas of knowledge required for the effective teaching of mathematical proficiency (Kilpatrick et al., 2001) and includes the need for sound relationships that support learning. A teacher needs to understand how knowledge is built upon and integrated into the existing knowledge base within the mind of each student (Bodner, 1986). The relationship between the teacher and students will influence how teachers engage with the curriculum and determine the learning that takes place in the classroom.

The knowledge of how to teach for mathematical proficiency

Knowing classroom practice means knowing what mathematic content is to be taught and how to plan, conduct, and assess effective lessons on that content (Kilpatrick et al., p. 379). Fundamental to all learning of mathematics in the Foundation Phase is the need for the teacher to have a sound understanding of how to deliver mathematics instruction. This incorporates the successful management of learning environments and developing classroom norms that support class discourse. Knowing how to go about instruction in a mathematics-specific class requires a kind of knowledge that Shulman (1986) has usefully termed pedagogical content knowledge.

The teacher needs to know how to carry out instructional procedures and practices and apply knowledge of concepts, procedures and processes in his or her teaching practice. The understanding and the carrying out of procedures are closely integrated and equally important. Kilpatrick et al. (2001) stress the value of questioning and conversation in a mathematics classroom, stating that the teacher must use these strategies to draw out students‟ ways of solving mathematical problems. According to the research findings of Schon (1991), this also requires the teacher to take on the role of reflective practitioner. In regarding oneself as a reflective practitioner, Schon (1991) asserts that it is essential for teachers to critically reflect on how effective their teaching is. This makes teachers conscious of what they do and what experience has taught them, developing their capacity to recognise, explain, and justify why they carry out instructional tasks the way they do.

All three of the knowledge types described above need to be incorporated into a teacher‟s practice if s/he is to provide students with meaningful learning opportunities. The quality of these opportunities is

important as a predictor of students‟ achievement and for the development of mathematical proficiency (Kilpatrick et al, 2001). According to the NCTM (1991, p. 6), “Classrooms should be mathematics communities that thrive on conjecturing, inventing, and problem solving, and that build mathematical confidence”.

2.4. TEACHERS’ BELIEFS AND ATTITUDES

In this section I pay particular attention to recent research in mathematics education indicating that teaching behaviour is influenced profoundly and often subtly by what teachers believe mathematics should be. Kilpatrick et al. (2001, p. 313) affirm that the “knowledge, beliefs, decisions and actions of teachers affect what is taught and ultimately learned”. Beliefs about the successful learning of mathematics may have a powerful impact on how children will learn and use mathematics. Beliefs also have the potential to become an obstacle to the effective learning of mathematics (Pehkonen & Törner, 1996). Some studies indicate a relationship of direct causality between beliefs and practices (Schoenfeld, 1992). Whilst Ernest (1991) maintains that beliefs wholly regulate a teacher's practice in the classroom, there is also evidence that changes in classroom practice may change a teacher's beliefs (Guskey, 1995). This change might then be regarded as learning. When an attempt is made to implement any new approach in mathematics teaching in the class, it would appear that the teachers‟ own view of what constitutes good mathematics teaching will strongly inform their decisions on instruction. Unless the new teaching method is in agreement with the teachers‟ own view of teaching, no matter what training is provided, the new approach will be to no avail. The individual teacher‟s own beliefs and views on teaching are the key to her practice (Lerman, 1993).

I question the teachers participating in this study on their beliefs, noting if they report any change in their attitude to teaching when using the SMC. As researchers make the assumption that a response to a questionnaire may reveal a belief system (Lerman, 2002), the relationship between beliefs and practices needs to be investigated. In South Africa research has revealed inconsistencies between the beliefs of mathematics teachers and their actual practice in the classroom (Brodie, 2001). The relationship between beliefs and practice has implications for current curriculum trends towards reform (Webb & Webb, 2008).

Various considerations regarding teachers‟ beliefs stem from:

- Teachers‟ professional attitude towards mathematics specifically

- Teachers‟ attitude to misconceptions and the teaching of mathematics
- The recognition of the prior knowledge of students and the attitude of the teacher towards the potential of a student to learn. Here a teacher‟s prior experiences could also be to the detriment of the student
- Professional status of teachers – this relates to the role the teacher perceives herself as having and her personal style of teaching
- Productive disposition of the teacher and her relationship with the students in her class.

When we consider teachers‟ beliefs and attitudes and how they impact on teaching, I make reference to Kilpatrick‟s et al. (2001) fifth strand, "productive disposition", which deals with the attributes of a teacher. In what way might beliefs and attitudes enhance or constrain the ability of a teacher to explore the envisioned curriculum as a coherent entity? Research shows that the teacher‟s knowledge and beliefs influence how the curriculum is interpreted and enacted in the classroom. The relationship between the enacted curriculum and teaching and learning in the class is largely dependent on the attributes of the teacher herself (Stein et al., 2007).

2.5 OBSERVATIONS FROM THE UNITED STATES ABOUT THE SMC

Comparative studies from various countries provide opportunities to ascertain the strengths and weaknesses of educational systems. Two pertinent reports pertaining to the Singapore mathematics programme were published in the later part of 2010 (Educational Research Institute of America [ERIA], 2010a; ERIA 2010b). The information in both reports refers to teaching for mathematical proficiency as discussed in 2.3, and thus was of particular value to my investigation.

2.5.1 2010 Educational Research Institute of America Reports (ERIA)

2.5.1.1 The first study

The first study was conducted by the (ERIA, 2010a) between 2009 and 2010, and focused on students in the second and fourth grades. The study included a pre-test and post-test based on the students using the "Math in Focus" programme.[10] The test scores of students were measured according to the American Stanford Achievement Test, Ninth Edition (SAT 9). This is a nationally standardised test,

[10] *Math in Focus* is the Singapore mathematics programme published by Marshall Cavendish Education, Singapore, in partnership with Houghton Mifflin Harcourt in the United States. It is the U.S. edition of the "*My Pals are here!"* mathematics programme used in Singapore and South Africa.

administered over a one-year period. The results showed significant increases in mathematics achievement among the 125 students using the Singapore curriculum.

The report also states that similar results were shown in a small scale pre-test/post-test study done in Nebraska in a school that used the "Math in Focus" programme.

2.5.1.2 The second study

The second study was an extension of the first, and also carried out by ERIA (2010b) between 2009 and 2010. In this study the researchers investigated the same Singapore Mathematics programme, "Math in Focus", operating in the state of New Jersey. The experimental group consisted of six teachers who have been using the Singapore curriculum since 2008, as well as 125 students who were tested against a control group of 553 students from twelve different schools in the same state. The control group followed an alternative instructional mathematics programme. Students from both groups were given a pre-test and post-test. The outcome measure was the state mathematics test named the New Jersey Assessment of Skills and Knowledge (NJ ASK).

2.5.1.2.1 The first research question that guided this quantitative study was:

Do students using "Math in Focus" in the experimental group show significant gains in math achievement at varying levels and how do they compare to the control group's achievements in mathematics?

The assessment of the experimental group in the spring of 2010 revealed that their scores were significantly higher than those of the control group. It was clear that the "Math in Focus" programme resulted in significant gains. The results were recorded and the scores were categorised into three proficiency levels, namely the partially proficient level, the proficient level, and the advanced proficient level. The descriptors per proficiency level are:

- **Advanced Proficient Level (APL):**

The students‟ achievement at this level clearly and consistently demonstrated thorough conceptual understanding of procedural and analytical skills. They demonstrated the use of abstract thinking and provided consistently clear explanations using both inductive and deductive reasoning to solve non-routine problems. They used multiple strategies and/or reasoning methods using various forms of

representations to solve complex problems. The scores revealed more students scoring at this Advanced Proficiency Level.

- **Proficient Level (PL):**

The students demonstrated proficiency in their recall, recognition and application of mathematical concepts, skills and vocabulary to solve problems involving real world situations.

- **Partially Proficient Level (PPL):**

The students who scored on the partially proficient level demonstrated limited recall, recognition and application of basic mathematical concepts, skills and vocabulary to solve problems involving real world situations. After the one-year study the number of students at this level of PPL was significantly lower.

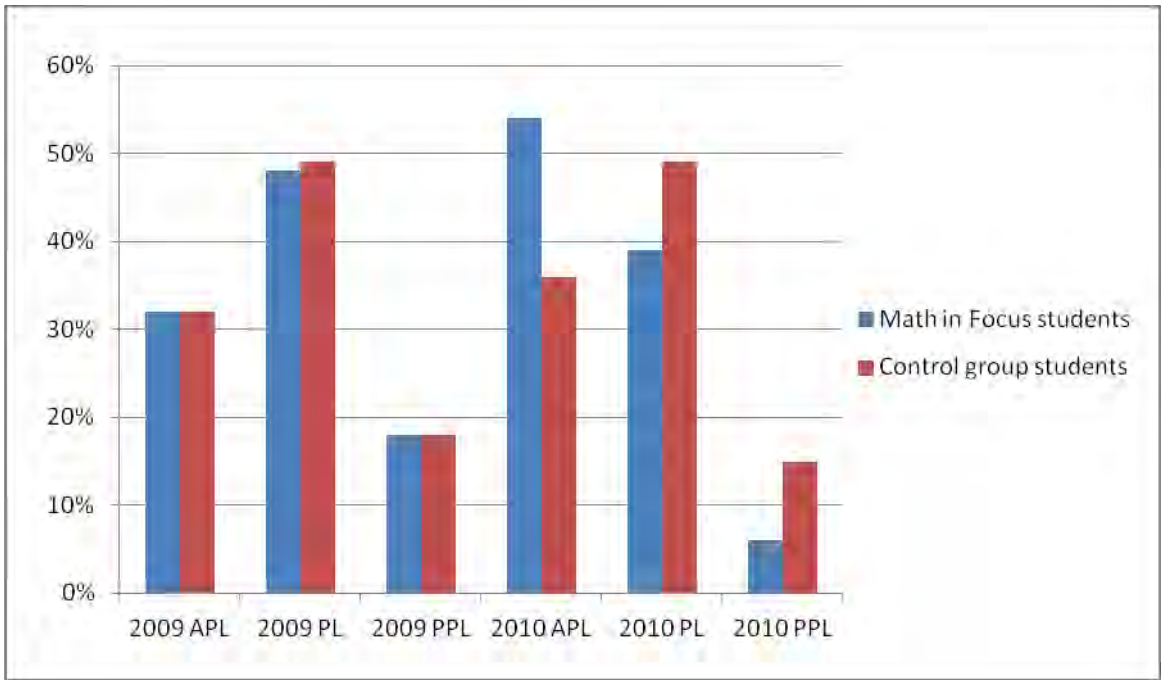
Table 2.3 indicates the trend recorded. Another encouraging discovery was that the partially proficient level students had improved the most in the experimental group.

	New Jersey Assessment of skills and knowledge proficiency level sub-groups		
Year of testing	Advanced Proficient level: APL	Proficient level PL	Partially proficient level PPL
2009	43	60	22
2010	68	49	8

Table 2.3: A comparison of the 125 "Math in Focus" students" results

Upon completion of the testing, the experimental group of students using "Math in Focus" were measured against a control group. The results of these scores were represented in percentages, again using the three NJ ASK performance levels for both groups of students. In the Advanced Proficient Level (APL), Singapore" Math in Focus" group percentage increased significantly from 32% to 54%; whilst the control group increased from 32% to 36%. In the Proficient Level (PL), the Singapore "Math in Focus" group percentage decreased from 48% to 39%, whilst the control group increased from 39% to 49%. In the Partially Proficient Level (PPL), the Singapore "Math in Focus" group percentage decreased significantly from 18% to 6%, whilst the control group decreased from 18% to 15%. The results are illustrated in Graph 2.7, indicating significant gains for the experimental group ("Math in Focus") in performing at both the Advanced Proficient Level (APL) and the Proficient Level

(PL). The improvement in the results revealed significantly fewer students performing at the Partially Proficient Level (PPL).



Graph 2.7 The comparison between the Singapore "Math in Focus" Programme and the control group recorded in percentages.

2.5.1.2.2 The second research question that guided this quantitative study was:

For students using the "Math in Focus" programme, does the performance on the state test (NJ ASK) correlate with a United States nationally standardised achievement test, namely the (SAT 9)?

The results furthermore revealed a strong correlation between the scores on both the state standardised and National standardised testing instruments that had been used.

2.5.2 REPORT 2: Evaluating the implementation of the Singapore Math Curriculum in 21 Hall County Elementary schools.

The Singapore Math Curriculum has been implemented in 21 Hall County Elementary Schools in the state of Georgia, and this progress report was released in August 2010 (Badger, Spence, & Velatini, 2010). It reported on a two-year study carried out from 2008 to 2010 by academics from the North

Georgia College and State University (NGCSU) departments of education and mathematics and computer science. It investigated the implementation of the new Singapore Math Curriculum through five primary questions:

a) Has the implementation of the Singapore Math resulted in higher student math scores?
b) Has the implementation of the Singapore Math had a positive impact on student interest and/or confidence in mathematics?
c) Has the implementation of the Singapore Math resulted in measureable changes in the teachers‟ attitude toward mathematics?
d) How do the elementary teachers implement the Singapore Math Curriculum?
e) Is there fidelity in the implementation of the Singapore Math curriculum?

Multiple means of data collection were used, both qualitative and quantitative. The first four primary questions were answered in the affirmative. Higher score rates were noted after two years. The teachers interviewed reported an improvement in the mathematics performance of students across the board. The key findings may be summarised as follows:

- The use of manipulatives in hands-on activities was a prevalent topic discussed by many teachers in a proactive way
- The more positive attitude of the students was attributed to the fun activities and enjoyment of the lessons and the use of colourful workbooks
- Teachers felt more confident to teach and reported a more positive attitude towards mathematics and the teaching of mathematics
- The English Language learners (ELL) in the United States found the curriculum to be vocabulary rich and often a challenge.

2.6 CONCLUSION

The Foundation Phase of schooling is vital in developing a positive attitude towards mathematics among students and providing them with a strong sense of number that will enables them to succeed in mathematics in the higher grades. Children who leave the Foundation Phase with a weak sense of number will “almost certainly never become strong in mathematics” (South Africa. DOE, 2009c, p. 21).

As highlighted throughout the literature discussed in this review, a key to ensuring the success in this

endeavour is the teacher. I have looked at the effect of teaching for mathematical proficiency using the SMC in terms of how it has promoted the necessary teaching skills indicates that the most important of these teaching skills can be considered to be:

- A positive attitude;
- Confidence to teach the subject;
- A reflective teaching practice, and
- The requisite knowledge base.

Appreciating that the individual teacher‟s own beliefs and views on teaching are a key to her practice (Lerman, 1993), I am interested to find out how the teachers translate the SMC into their own practice.

Chapter 3 describes the methods used to collect information about the influence of the SMC and its contribution to the development of teachers in terms of the characteristics of good teaching practice noted above.

CHAPTER THREE
RESEACH DESIGN AND METHODOLOGY

> If research is to be worth the effort, it needs to offer the prospect of going beyond competing ideologies, to offer the possibility of changes in our thinking and practice.
>
> (Winter 1996)

3.1 INTRODUCTION

In the previous two chapters I adumbrated the context of my research and reviewed the literature pertinent to it. This chapter deals with the research design and methodology used. Since I was seeking to understand the teacher as a person from within, instruments were chosen to gather data that would best describe the experiences of individual teachers. Thus I video-recorded interviews and classroom lessons, as well as interaction and dialogue between teachers in the focus group.

Teaching for understanding, as promulgated by the SMC, is based on the principles of constructivism (Singapore. MOE, 2009), as is the model of teaching for mathematical proficiency proposed by Kilpatrick et al. (2001). The ontological framing and epistemological principles that underpin this research study are therefore located within a social constructivist framework.

3.2 RESEARCH GOAL

The goal of my research was to investigate the classroom experiences of a group of six Foundation Phase teachers in the Eastern Cape of South Africa. The particular objective was to consider the teachers‟ experiences of implementing the SMC, as individuals and as a group. In other words, I sought to analyse how the SMC informed the teaching practice of individuals as they implemented the SMC. The research goal informed my research methods and choice of research instruments.

3.3 THE CHOSEN PARADIGM

This study was located in an interpretive paradigm and was interactional, interpretive and qualitative in nature (Terre Blanche & Durrheim, 2006). According to Cohen et al., “The interpretive paradigm is characterised by a concern for the individual” (2008, p. 21). In this case, the individual teacher was the

point of focus, and an attempt was made to understand the subjective world of her experience. The research also afforded me the opportunity to interpret and comprehend the experiences within set contexts. The qualitative approach to this research allowed me to consider people‟s thoughts and feelings – especially the events and situations conducing to the different experience of each teacher (Maxwell, 1996). Maxwell elaborates on this qualitative approach, pointing out that unpredicted or unexpected situations may arise, and suggesting how this can influence the research study. I took cognisance of this caveat, which required me as a researcher to be more understanding and open to unplanned happenings. This included personal issues beyond my control.

3.4 RESEARCH METHOD

This research focused on a group of teachers and the effects of the SMC on their individual teaching practice. Since it was a small-scale study that focused on a moment in time, I found the case study method appropriate, "the study of an instance in action" (Cohen et al., 2008, p. 253). This case study thus investigated and reported the dynamic and unfolding interaction of events, human relationships and other factors in a unique situation.

As reflective practitioners, each teacher used a research journal to record their unique experiences of teaching. Their thoughts and challenges were then aired in focus group discussions, and the resultant combination of subjective and objective information was important.

The teachers were encouraged to incorporate the five broad, intertwined components of Kilpatrick et al.‟s (2001) conceptual framework on mathematical proficiency within their own classroom practice. Their self reflection, with regard to varying experiences and responses from students, was recorded in their journals. The journal also afforded the teachers opportunities to express their thoughts and feelings about the process at any stage. What was of significance when working alongside teachers in a case study was that proficiency in teaching can potentially be learned, and the focus group provided an opportunity for teachers to engage with each other to this end. I obtained data from individual teachers as well as from discussion within the focus group.

Qualitative research may be seen as a „window‟ through which we might „see‟ and comment on significant issues pertaining to what and how teachers go about their business of teaching. By making

use of questionnaires and semi-structured interviews, I was able to gather in-depth information about each individual teacher. Conversations followed each of the lesson observations, and this gave teachers in the focus group time to share information about their practice and raise pertinent questions about the varieties of pedagogy observed. The discussing of the knowledge base required when teaching for mathematical proficiency was aided by a framework for observing lessons (Appendix A). This schedule also served as a guide for the teachers in their own daily practice.

3.5 RESEARCH SITE AND PARTICIPANTS

I chose teachers from Grade R to Grade 3 in the Foundation Phase of South African schooling , at schools where the Singapore Mathematics curriculum is currently being taught. The students range in age from five to nine years old. I restricted my choice of schools to the Eastern Cape, due to their close proximity to my workplace. My preferred research site also included the school where I am currently the principal. There were only two schools implementing the SMC in the Eastern Cape when I commenced my research, a private co-educational preparatory school and a public (former model C) school for girls. The choice regarding members of the focus group was made with care. I wrote to the head of the primary department of the private school (School A) for permission to carry out research and requested a meeting with teachers in the Foundation Phase interested in the proposed research (Appendix C). There were two teachers who readily volunteered to be part of the focus group and were particularly keen to work alongside a neighbouring school. As the principal of the second school (School B), I sought the approval of the School Governing Body for this research project (Appendix D). I needed to approach the selection of teaching staff with sensitivity, realising that all the teachers could add value to the study. All class teachers were invited to participate in an information workshop, on the understanding that it was entirely voluntary and that all meetings and data generation would take place outside of school hours. There were six volunteers from my school who attended the first workshop to outline the process and assure each teacher of her anonymity and the right to withdraw at any stage. (One interested teacher had already written to me to withdraw from being considered for the group because of the time constraints upon her.) The final group consisted of six out of a possible twenty-four practising classroom teachers. The selection was therefore based on voluntary participation and the participants‟ willingness to share their teaching experiences with a research group.

The teachers have proved pivotal in piloting the implementation of the SMC during 2010 and 2011. The sampling comprises teachers with different teaching styles and beliefs in mathematics, who were willing to commit to ongoing collaborative group work and be reflective practitioners within their own classes. What could have presented itself as a problem was that one member relocated in the early stages of the study to Taiwan. However a volunteer from the initial stage stepped in as a replacement. Another potential problem encountered was when a teacher became pregnant. Together we adjusted the time frame for her and completed her interview and recordings of lessons before she went on maternity leave. Even when Teacher E went on leave, she remained committed to the focus group and never missed a meeting or workshop. Members of the focus group developed relationships of mutual trust and were able to speak out about support they required or ask for assistance from fellow members.

3.6 DATA COLLECTION AND DATA GENERATION

A variety of techniques was employed to collect data from individual members of the focus group and the focus group itself. Cohen et al. (2008, p. 253) state that case study research has the potential to "penetrate situations in ways that are not always susceptible to numerical analysis". This is because it uses different and various tools in collecting information about a chosen topic. I found this approach useful as it helped me obtain information from more than one perspective. Whilst the data collection was a recursive process, it occurred within four stages. The research instruments chosen are discussed within the different stages of the process. These activities came together to form a cycle of events, as illustrated in figure 3.9.

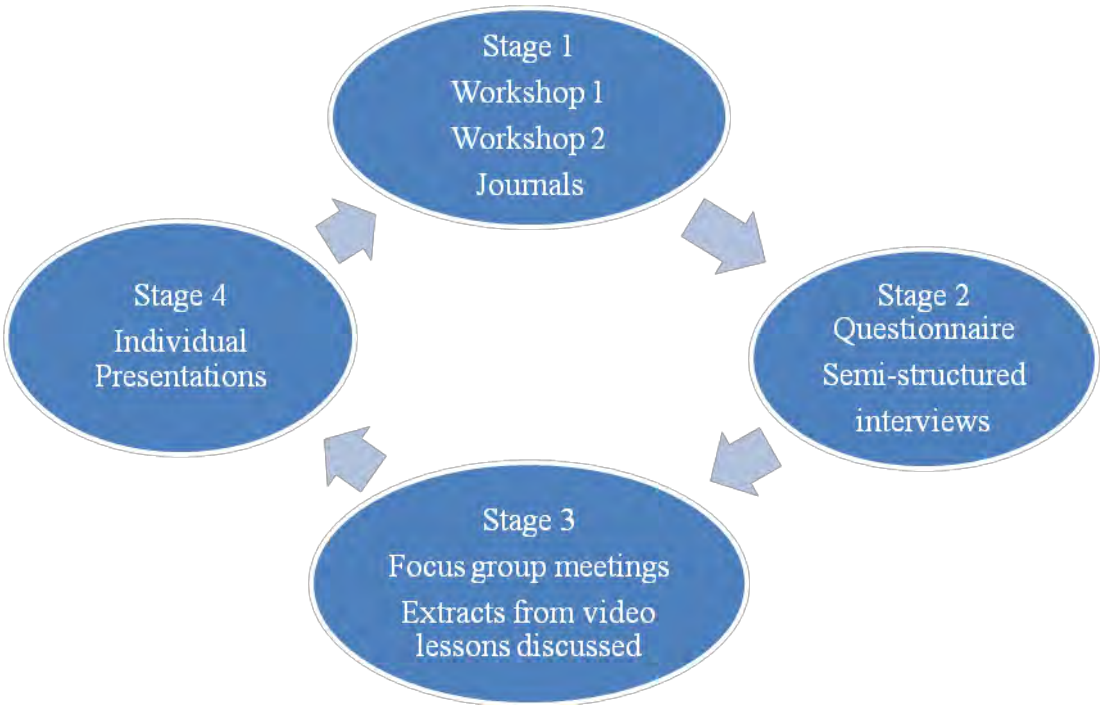


Figure 3.8 Stages of data generation

3.6.1 Stage 1

- At the outset I held two workshops, to which interested teachers from each school were invited. The purpose of the **first workshop** was to introduce the teachers to the notion of teaching for mathematical proficiency according to a conceptual framework (Kilpatrick et al., 2001). This framework served as a tool for analysing teacher practice within the SMC curriculum. Open communication and a time for questions ensured all were comfortable with the academic research proposed in this study. Subsequent to the initial meeting, the focus group was formed. The minutes of this workshop are presented unedited in Appendix G.

- The **second workshop** was held to constitute the focus group of six teachers (Krueger & Casey, 2000). It gave teachers the opportunity to get to know each other and establish a rapport with one another. The meetings to follow were to be informative meetings with a particular focus on the envisaged case study. The conceptual model of teaching for mathematical proficiency was revisited, with discussion on the pointers (Appendix A) to further assist teachers in their understanding of the need for their teaching practice to be recorded. All participants were presented with files with relevant reading materials and guidelines.

- The participating teachers were introduced to the notion of being a reflective practitioner by making use of field notes or a **personal journal.** The recording of quick notes, key words or

longer descriptions may be done in this way. Using a journal in this way has been shown to increase the validity of a teacher‟s ability to make accurate and critical judgements on the quality of their ideas in general (McCrindle & Christensen, 1995). Each teacher was presented with a colour-coded journal for anonymity and all their data is recorded according to pseudonyms. I felt that a journal was a useful tool for collecting data in which teachers could record their thoughts and be afforded a voice concerning their personal experiences throughout the study. Participants were also encouraged to reflect on their own practice of teaching the SMC. They were also asked to reflect on their participation when attending workshops or after the focus group discussions which were held during the entire five-month research process.

As stated previously, qualitative research may be regarded as a „window‟ through which we might „see‟ and comment on significant issues pertaining to how teachers go about their business of teaching for mathematics proficiency. My core responsibility in this research is to make sure that the „window‟ stays open by maintaining and collecting all notes provided to the focus group, and recording interviews, observations and the entire research process within my own filing system.

3.6.2 Stage 2

Each teacher was asked to complete **a questionnaire** with three separate sections. The questions dealt with the individual teacher‟s background profile, her views on mathematics, and how she rated teaching the SMC (refer to Appendix B for specifics). According to Hofstee (2009), “A questionnaire is a form of structured interviewing, where all respondents are asked the same question and offered the same options in answering them” (p. 132). In my questionnaire I also asked a number of open-ended questions at the end of each section. This was to allow each teacher to express herself in her own words, which helps put the respondent at ease and give them a sense of control (Hofstee, 2009).

1. Section A of the questionnaire dealt with the teacher‟s personal particulars, including age, teaching qualifications and years of teaching experience within the foundation phase of a school, including the specific grades. This first section was adapted from Furner **(**2004, p. 45).
2. Section B posed questions relating to their view of the nature of mathematics. Each question was designed to have either a positive or a negative valence. Section B of the questionnaire was adapted from the Standards‟ Beliefs Instrument (SBI) compiled by Zollman and Mason, (1992).
3. The final section C related specifically to the SMC curriculum, and asked them to rate specific aspects of teaching the SMC. I posed the questions in such a way as to align them with the

notion of teaching for mathematical proficiency, as advocated by Kilpatrick et al. (2001). This included determining if they regarded problem orientation at the core of teaching the SMC. Questions also probed the extent to which logic, creativity and games were being incorporated in the curriculum, along with the understanding of concepts and skills in carrying out procedures. Being able to explain one‟s thoughts in a coherent way and representing one‟s thoughts on paper comprised another important component of the rating of the SMC. The 12 questions were presented in the same way as Section B, with rating on a scale of one to five. As the teachers were currently engaging with the programme and the answers ranged from strongly disagreeing to strongly agreeing, the intention of this section was to allow them a voice to share their impressions of some of the key features of the curriculum. It was also designed to elicit their personal beliefs concerning certain teaching practices. I captured all the information per teacher in separate graphs. Discussing the findings from each teacher per question was dealt with in the synthesis of their responses.

I also drew up a schedule of questions for **semi-structured interviews** for each of the teachers in the focus group (Appendix E). Cohen et al. (2008, p. 353) refer to this type of interview as adopting an "interview guide approach", in which the topics and issues to be covered are specified in advance. The guided outline will "increase the comprehensiveness of the data and make the data collection systematic for each respondent" (Cohen et al., 2008, p. 353). I catered for the weakness of this approach by allowing the respondent to deviate to include salient topics that I may have omitted at the outset. I hoped to elicit information regarding the challenges, opportunities and possible anxieties experienced by the individual teacher when she was engaging with the SMC. Taking note of the guidelines outlined by Ashworth (2001. pg. 311), I gathered that the interview should be regarded as a conversational partnership in which the interviewer assists a process of reflection. The participants were encouraged to share their interpretations of questions based on an interview framework covering the SMC, teaching practice and ways to teach and implement a curriculum. Key topics deemed important in the interviews were:

- what constitutes maths knowledge for teaching;
- dealing with specific examples of their source of inspiration and reward in teaching SMC;
- how they implement the curriculum;
- the balance between conceptual understanding and carrying out procedural tasks;
- challenges and limitations within the SMC;
- the resources including textbooks, workbooks and manipulatives as specified in the SMC;

- the prescribed lessons and tasks within this curriculum;
- time considerations;
- the spiral curriculum approach to teaching and learning across the grades, and
- considerations regarding how children learn.

Embarking on a recorded interview has the potential to create a level of apprehension. I hoped that by focusing on the purpose of the research and encouraging each teacher to share her experiences (without any fear of giving a "wrong" answer) would ease any anxiety. The transcriptions reported each teacher‟s conversation using a pseudonym to ensure confidentiality, as per our agreement. The beginning of the interview for me was the opportunity to allay the teacher‟s fears of having her responses recorded, and here simple introductory questions relating to the students in her class were asked. The questions put forward were open ended and designed to allow the teachers freedom to share their own experiences when using the SMC. There was no need for intervention unless greater clarity on an answer was required, and all the participants were interviewed according to the same framework of questions. Refer to Appendix E for an interview schedule.

3.6.3 Stage 3

During this stage the **focus group** discussions were scheduled to take place. The goal of eliciting teachers‟ opinions, attitudes and perceptions about their own practice was central to the focus group interviews (Puchta & Potter, 2004). Focus groups are a form of group interview and their use in educational research appears to be growing. The researcher relies on interaction within the group, who discuss a topic supplied by the researcher to yield a collective rather than an individual view (Cohen et al., 2008). The sharing of opinions and exchanging of viewpoints afforded the group a collaborative approach to sharing their teacher practice. My role as a facilitator in this regard included:

- minimal use of prepared questions, balanced with open-ended questions;
- engaging in empathetic listening to hear meanings, interpretations and understandings;
- consciously remaining silent about my own concerns, pre-occupations and judgments, and
- using prompts to pursue and clarify the participant‟s own line of reflection and allow the participant to elaborate, provide incidents, clarifications and maybe to discuss events at length.

Being able to video-record mathematics lessons at both schools provided a wonderful basis for discussion at a focus group meeting. The purpose served by the **extracts of video recordings** in the focus group discussions was twofold. Not only could teachers observe the actual SMC teaching practice of colleagues taking place in a classroom at both the selected schools, but the video recording served also as a mirror lesson within the focus group for discussion and reflection. The consent of teachers as well as permission from the parents of the pupils in the classroom was gained (Appendix F). In some instances, viewing videos took place as a discussion point with extracts being introduced into the group discussions as either a stimulus for discussion or a tool for teaching. The focus group conversations and observations shared were based on specific sections of the recordings and all comments were recorded and transcribed. In the synthesis of all this data, I used the **lesson observation schedule** on teaching for mathematical proficiency (Appendix A) as a conceptual framework within which to collate the observations and experiences that the teachers shared.

In order for an observation schedule to be reliable, it must be applied consistently and it must be structured in a way to prevent variation in interpretation. The schedule was given to each of the teachers prior to their observing the video recordings. I regarded it as a powerful tool for gaining insight into situations.

3.6.4 Stage Four

The final stage of the data generation consisted of **individual presentations** from each member of the focus group. Each member of the focus group was afforded the opportunity to present their own experiences with the SMC at a workshop towards the end of the research process. The format and choice of presentation was left to the discretion of each teacher. This included power-point presentations, clips of videos, handouts and other artefacts, as well as mock activities extracted from lessons. My supervising professor from Rhodes University was able to be present at this final presentation from the focus group, held on the 12th of March 2011 in East London.

3.6.5 Reflections in journals occurred throughout all the stages

Extensive writing and recording of a personal nature regarding each teacher‟s experiences with the SMC was noted in the personal journals. This vast quantity of information provided further insight into the thinking of the teachers when they were implementing the SMC. They were encouraged to record what they deemed to be working well as well as what presented challenges or frustrations. Teachers

requested assistance and I provided them with guidelines for teaching for mathematical proficiency (Appendix H). The teachers were free to record their thoughts, to note specific features of the curriculum they felt strongly about or highlight any aspect of their experience in the journal. They were also encouraged to express such goals and aspirations as they might have regarding their own teaching practice.

3.7 DATA FINDINGS AND DISCUSSIONS

3.7.1 Introduction

In my analysis of the data, I was mindful of treating all of the teachers‟ feedback with the utmost respect. The qualitative research orientation allowed me to „see‟ and comment on significant issues pertaining to how each of the teachers went about implementing the curriculum and what their experiences were. All the data was analysed and collated in three phases, as indicated in figure 3.10:

Figure 3.9: The three phases of data collection

3.7.2 Phase 1: The individual teacher profiles

- Personal background

The findings and discussions in this first phase pertained to each teacher‟s personal background. The data were attained through the teacher profile questionnaire (Appendix B: section A). Whilst this was a valuable research tool, I also made use of material gained from informal interviews conducted in the course of the case study.

- Personal beliefs and experiences

The data was obtained from the questionnaire, with specific reference to Appendix B: section B, regarding how the teacher viewed the nature of mathematics. The semi-structured interview afforded me answers to some of the questions relating specifically to how the teacher felt and what her own experiences had been. The journal writings afforded me even greater insight into each teacher‟s personal disposition towards mathematics.

- Teaching the Singapore Mathematics Curriculum

Each teacher was afforded an opportunity to present her own experiences at the final stage of the case study. These presentations were unique and extremely personal renditions of the individual teacher‟s experience. Some were in the form of a power point presentation, with or without handouts. Other teachers chose to use visual aids to illustrate what had been of particular significance to them in their teaching experience. The video recording of different lessons and the feedback and discussions around these lessons formed an invaluable set of data. Each time the focus group discussed lessons they had observed the session was video-recorded.

- Rating the SMC

The questionnaire section C (Appendix B) allowed each teacher to rate the SMC on a scale from 1 (strongly disagree) to 5 (strongly agree). The ratings per teacher are presented in graphs 4.1 to 4.6. Each graph is then discussed according to the findings from each teacher.

3.7.3 Phase 2: The workshop and focus group discussions

- Workshop 1: No data was collected as this first workshop was an orientation workshop. The minutes of the first workshop are attached in Appendix G.

- Workshop 2: No formal data was generated as this was an interactive workshop where teachers could ask questions for clarity about the process. They were presented with supportive material including a checklist for teaching for mathematical proficiency (see Appendix H). Some reflections after this workshop were entered in the teachers‟ journals.
- Focus group meetings were to observe and discuss video-recorded lessons. As the teachers talked to each other, their conversations were captured on video.
- Focus Group Presentations: The individual members of the focus group presented their experiences and story at the final meeting. I captured all these stories in my field notes. Along with the handouts presented to members of the focus group, an enormous amount of information was able to be discussed and much data was generated from these presentations.

3.7.4 Phase 3: The synthesis of data findings

Having considered the teachers‟ individual and collective experiences, I used the observation schedule (Appendix A) to synthesise all the data. The five strands encompassing teaching for conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition were referred to as I linked data from the different experiences to discuss the findings.

3.8 ETHICAL CONSIDERATIONS AND RESPONSIBILITY

The participants had the freedom to withdraw at any stage of the process and their voluntary participation assured them anonymity at all times. After I had gained the consent of all the teachers and received written consent forms from all the parents of the students concerned, I thanked the students for allowing me to video record during their mathematics lessons. Having agreed to anonymity, some members of the group subsequently felt that they would prefer their names to be recorded as evidence of the validity of the findings of the study. As researcher, I remain committed to the initial ground rules. The validity and reliability of the analysis of the results could be in jeopardy in the event of individual teachers and schools being named.

3.9 VALIDITY AND RELIABILITY

From the academic research I have been exposed to, I have gained an awareness of the commitment to impartiality and integrity associated with the capturing and analysing of data. From my observations

and study of the data presented, it was my responsibility as the researcher to present as sound and impartial a report as possible. My position as head of one of the schools was not allowed to compromise the objectivity of my role within this research study (Cohen et al., 2008, p. 120).

Copies of transcripts were made available to the participants to help secure the interpretive validity of the research (Maxwell, 1992). This not only helped to confirm the accuracy of the transcriptions, but also allayed suspicion regarding the power that might be associated with the gathering and concentration of information in one pair of hands. As researcher I excluded any of my own experiences within the community of practice and focused on the teachers‟ viewpoints. I was as honest and transparent as possible from the outset to ensure that there were no misconceptions or misunderstandings. A reciprocal non-judgemental spirit was agreed upon by all participants at the outset. A respect for all teaching styles and for the individual members of the group was non-negotiable. This was aimed at reducing or minimising the potential problem of bias, as noted in some case studies (Cohen et al., 2008, p. 256). I ensured that all the raw data from my research was safely stored and available upon request. All the participants were treated with sensitivity and integrity. According to Sherman and Webb (1988), the aim of qualitative research is not to try to verify any predetermined idea, but rather to make discoveries that lead to new insights.

3.10 LIMITATIONS

In this study the participants were all volunteers who willingly committed to share their experiences and practices in the focus group. Whilst all workshops and meetings took place outside of the school day, the time constraints did not result in any member requesting to be released from this commitment.

The case study investigates the practices of a group of English-speaking, female teachers in two well functioning schools. There were thus no teachers from under-resourced or low performing schools in this study. These characteristics of the sample in the study may be deemed as limiting the study. Considering the more typical profile of South African schools and the fact that the vast majority of schools within the Eastern Cape are under-resourced, the option of this project being extended to neighbouring township schools should be considered.

3.11 CONCLUSION

This chapter orientated the research in the interpretive paradigm and provided details of the choice of methodology and instruments used. It also reminded the reader of the goal of the research and described the research site and selection of the participants. Whilst it was indeed a privilege for me to work alongside teachers who allowed me into "their world", I also gained new insights into a community of learners who enthusiastically participated in the SMC lessons. My approach to the process of collecting and analysing data was described. The chapter ended with some consideration of questions of validity, ethics and limitation. The analysis of the data is dealt with in the next chapter.

CHAPTER FOUR
FINDINGS AND DISCUSSION

> Reflective teaching entails a recognition, examination, and rumination over the implications of one‟s beliefs, experiences, attitudes, knowledge and values as well as the opportunities and constraints provided by the social conditions in which the teacher works.
>
> (Zeichner & Liston, 1996)

4.1 INTRODUCTION

In this chapter, I present the data findings as they occurred in the three phases illustrated in figure 4.11. In the first phase I focussed on each of the individual teachers. This included listening to their unique experiences in teaching the SMC, I list these in the individual teacher profiles. Direct quotations appear in a different font (Albertus medium)**.**

The second phase consisted of finding data based primarily on the conversations held during the focus group meetings. During these discussions, the teachers considered the pros, cons and challenges of the experience. Watching recorded lessons of each other‟s teaching and recording the discussions was extremely informative. Most of the data comes from discussions about the extracts of class lessons.

In the third phase I considered the individual teacher‟s perspective first. Second, I was able to consider all the evidence from the group perspective and present my analysis based on what was argued by Kilpatrick et al. (2001). I merged the discussions and data cross referencing to form a rich melding of all the teachers‟ practices and experiences. Kilpatrick‟s five strands of teaching for mathematical proficiency formed the sub headings in this phase.

Figure 4.10: The three phases of data analysis

4.2 PHASE 1: THE INDIVIDUAL TEACHER PROFILE

- Personal background

The findings and discussion in this first stage pertain to the personal background of the teachers. This data was acquired through the teacher profile questionnaire (Appendix B: section A). Whilst this was a valuable research tool, I also use informal interviews as they occurred in the natural course of the case study. I focus on each of the individual teachers in their individual contexts, listening to their unique experiences in teaching the SMC in phase 1. I present the data collected from the individual teachers A – F in the different stages as set out in the methodology chapter.

- Personal beliefs and experiences

The data obtained from the questionnaire with specific reference to Appendix B: section B, relates to each teacher‟s feelings and perceptions about mathematics and how they view the nature of mathematics. The written journals also provide insight into their personal disposition towards mathematics. The semi-structured interviews allowed the teachers to express their feelings.

- Teaching the Singapore Mathematics Curriculum

Video recordings were taken of various teachers during their mathematics lessons. The feedback and discussion around these lessons during focus group conversations formed an invaluable set of data. The focus group was also video recorded.

- Rating the SMC

In section C of the questionnaire (Appendix B) each teacher rates the SMC on a scale from 1 (strongly disagree) to 5 (strongly agree). The ratings per teacher are presented in graphs 4.1 to 4.6. Each graph is analysed to determine how strongly each teacher felt about certain features of the SMC. I am aware that the graphs should consist of discrete points, but chose this representation for visual effect. What was of significance in the overall result was the relationship between the teachers‟ views and beliefs and how this informed how they rated the SMC. Some teachers used their journals to reflect on their teaching experience and on the opportunity to be part of a focus group. The journals proved to be a valuable information tool.

4.2.1 Teacher A

4.2.1.1 Personal background

Teacher A is a married woman who has two teenage daughters. She has taught both in Gauteng and the Eastern Cape. She has nineteen years of experience ranging from Grade R to Grade 2. She is in her early forties. She admits mathematics was not her favourite subject, but acknowledges the importance of mathematics both in the classroom and in life in general. She first taught the SMC in Grade R and is currently teaching in Grade 2. Some of the students who were in her Grade R class two years ago are with her this year.

Teacher A started teaching in 1994. This coincided with strong political change and teacher A realised this would have an impact on her teaching career. She acknowledges that we live in changing times and that is evident in her reporting on the practices in her classroom.

4.2.1.2 Personal beliefs and experiences

Both the teacher and I, as researcher, found the recorded interview a daunting task at first. As researcher I had to reaffirm the negotiated agreements of this case study.

The fear of mathematics and getting answers wrong as a student at school was a reality experienced by Teacher A. Teacher A recalled not being very good at mathematics when she attended primary school and how she avoided mathematics homework whenever she could find an excuse. Her difficulties in mathematics were reflected in low test scores at high school. Despite extra lessons at high school, she remembers how she couldn't picture the theories in her mind. She readily admits having had little understanding of many concepts and lacked strategies to solve problems. She had no confidence in mathematics and in fact regarded herself as really bad at mathematics. This negative notion she portrayed in the class as a student affected her teaching of mathematics in that she became reliant on following the specific syllabus and focussed on teaching the prescribed content. She felt comfortable with the Foundation Phase level of mathematics as she could do "the basic mathematics".

Attending a Singapore mathematics course in Gauteng changed her approach to teaching mathematics. This included her perceived view of mathematics. She was introduced to the model method in problem-solving. Achieving a 70% mark at the end of the course restored her confidence in both herself and her belief that she could do mathematics. In particular she appreciated how the bar model technique could be applied to very simple problems and also to difficult multi-step problems. The bar modelling tool helped her to represent work visually. She enjoys sharing her experiences and acknowledges how she has grown in her understanding of mathematical knowledge. She found her first year teaching SMC to Grade R easy and liked the very practical approach where concepts were reinforced when students used a workbook. Being able to teach some of these students again two years later has been beneficial in experiencing the spiral curriculum.

Teacher A readily shares her knowledge and is open to change as she recognises teacher development to be a lifelong process. She reported critically on her previous teaching experiences. Her candid reporting on how she manages teachers within a grade was noted. She values shared practices and states the SMC allows you to question your role as a teacher and reflect on what needs to change in order to enhance teaching and learning in schools today. Good teaching depends on knowledgeable, flexible and reflective teachers. This is in line with the research and espoused by Kilpatrick et al. (2001).

4.2.1.3 Teaching the Singapore Mathematics Curriculum

Teacher A‟s fears of mathematics have slowly changed as she has gained confidence in using a curriculum which makes her feel comfortable. She values the importance of children making sense of number. Her initial sceptical view-point of implementing a foreign curriculum has been a specific area of growth for her. She realised how the SMC mathematics vocabulary can raise the level of speaking and understanding the language of mathematics. A further change acknowledged by teacher A is that the SMC has a child-centred approach. She claimed she took a strong lead from the teachers‟ detailed guideline manual on how to go about the teaching of the SMC.

She acknowledges how helpful both the SMC teacher manual and the other SMC resource books are. They assist her in the actual planning of lessons. The choice of games and ideas provided in the manual has given her a new focus in her lessons. Previously she told the children what and how to do mathematics. Now she feels she questions and provides opportunities to the students to learn and discover on their own. She likes to talk about relationships between numbers. Teacher A also shared the view that her insecurity and fear of mathematics has slowly changed due to using a curriculum that she feels comfortable with, and she now understands the importance of children making sense of number. Her earlier scepticism concerning implementing a foreign curriculum related to the choice of mathematics vocabulary. The level of speaking and understanding the language of mathematics had been raised in her class and the focus on communication and understanding was paramount.

The disposition of Teacher A towards mathematics is a crucial aspect of her teaching. She described how her attitude to mathematics and her role as a teacher have both changed. She can testify to the worth of mathematics. Both she and her students are more confident since using the SMC. This confidence has afforded her more freedom in her teaching as she has been able to share more openly with students in her class. She is more positive towards mathematics and her delight in achieving good results is a reward in itself.

Her role of teacher has become more of a facilitator. This allows her students the opportunity to discover and come up with their own solutions to problem solving. She is empowered as a teacher and is continually open to change. She places equal importance on the understanding of concepts and the

fluency in which you carry out operations. She values the notion of teacher development being a lifelong process. Previously her emphasis was on **practise and practise until you get the right answer.** She described how her role of asking questions to encourage students to think at a much deeper level has developed. She reports that she listens now instead of just telling children how to solve a problem and she now focuses on encouraging children to discover and share their methods and discover solutions in different ways. She feels she has managed to change her approach to teaching and values sharing her practice about SMC with others and acknowledges that the focus group experience has been of particular value to her.

One specific feature of the SMC which she has enjoyed is the model method. This was a turning point for her as a Grade 2 teacher. She is always open to learning new things which mean changing from old to new methods, from what doesn‟t work to attempting something new. Trying to make sense of this model method has been part of planning among the grade teachers and she acknowledges that not all teachers have embraced the change and try to incorporate extra content or methodology from the SMC as this can cause confusion and stress among some teachers. The sense is that one should be focused on a particular curriculum framework and stick to it until you are confident enough to try variations or creative new activities.

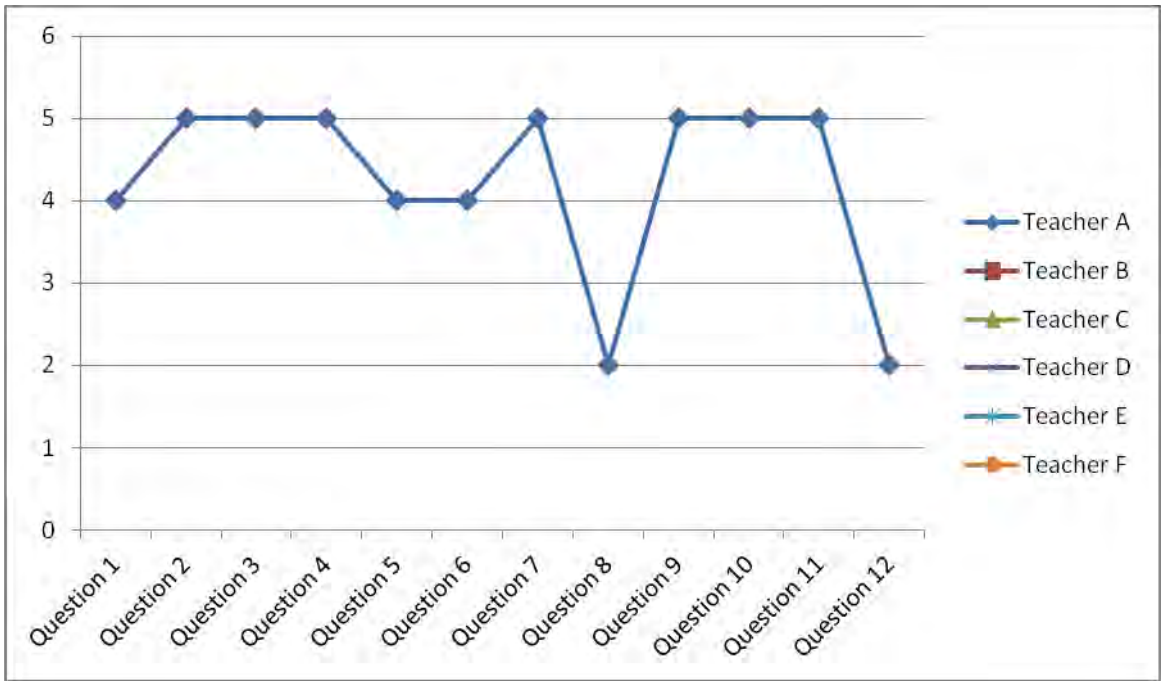
Teacher A feels her class in general is a lot happier when working with number and she feels the students perceive her as enjoying teaching mathematics. The reduction of anxiety has been the greatest revelation in her own teaching of the SMC. Good communication skills are now viewed as essential tools when teaching and learning mathematics. Allowing children to verbalise what they do not understand and learn from their mistakes in a positive, non-judgemental way are contributing factors to less stress in the classroom. For her, the role of language is very important and certain vocabulary needs to be understood in practical terms. A student commenting, **Teacher A, you love maths and I also love maths because I can do it,** has been her greatest reward in teaching the SMC this year.

4.2.1.4 Rating the SMC

Teacher A refers to herself as a visual learner and therefore agreed most emphatically with the 3 step approach to all learning by using the concrete-pictorial-abstract approach as discussed earlier in chapter 2. Describing the importance of communicating thoughts on both paper and verbally, she shared how she had changed as her classroom practice now encourages sharing ideas. She disagreed with the notion that specific methodology takes priority. She explained that there are different ways of

solving problems and disagrees that formality and specific methodology occur in Grade 2. She highlighted the more flexible approach to ensure understanding in the SMC. She disagreed that the practice and drill are sufficient in SMC and calls for extra exercises in this area.

Graph 4.1 shows how Teacher A rated the SMC as per the questionnaire (Appendix B)



Graph 4.1 Teacher A"s rating of the SMC

4.2.2 Teacher B

4.2.2.1 Personal background

Teacher B specialised in Early Childhood Development and studied for five years in the pre-school phase. She has never taught outside of the Grade R class in her 15 years of teaching. She embraces professional development and is continually keeping abreast of trends in education. She first implemented the SMC and the resources in 2009. As a married mother with a daughter and son in the Intermediate phase of schooling, she relates to the role of parents in a very practical manner. She regards the co-operation between school and home, as promulgated by the SMC, as an important partnership.

4.2.2.2 Personal beliefs and experiences

Teacher B is always keen to learn and gain greater knowledge and insight into how to improve one"s practice. She stated she has an enquiring and analytical mind and is always looking for answers to

problems. She travelled to Gauteng in November 2008 for training in the SMC. She was particularly interested in the flow of concepts starting with the discovery, hands-on approach which she appreciates. She embraces the informal knowledge of children who enter school with varying levels of knowledge. She admits that previously the teaching of number work was at possibly too basic a level. She acknowledges there was little emphasis on actual mathematics knowledge and terminology in the past, now she has introduced more mathematics vocabulary in the lessons.

4.2.2.3 Teaching the Singapore Mathematics Curriculum

Teacher B has always loved maths and SMC has not changed her attitude towards mathematics. What she admits has changed is her role as a teacher and how she pays more attention to how she asks questions. She feels SMC provides the opportunities for students to engage in maths activities in a fun, yet challenging way. She is constantly trying to reflect on her teaching role as well as the SMC and tries to adjust her activities to incorporate what she feels is important in the teaching, learning and discovering of patterns in mathematics. She values the structure of the lessons and has regarded the use of two workbooks in the reception year as being a positive experience.

The hands-on activities and real life learning situations sit well with her teaching style. She writes in her journal how the children enjoy discovering number sense for themselves and also interacting in pairs or groups in the different activities. She focuses on how the children enjoy working with numbers and acknowledges the importance of developing their conceptual understanding through play. What has changed is her use of the various teaching strategies which the SMC promulgates. She is more aware of the needs of the students and encourages them to share their "new-found knowledge".

The spiral curriculum espoused by SMC affords Teacher B a new way to approach the teaching and learning of mathematics. In particular, getting to know and understand the prior knowledge young children bring into the classroom is possible through the SMC systematic approach. She stressed her appreciation of teaching the Singapore Mathematics with a clearly set out spiral curriculum in her final presentation. Her expectations of the learning opportunities have been raised when implementing SMC at this early formative stage of schooling. Although she acknowledges the impact of a set numeracy period in each day and a somewhat more formal manner using the SMC, she feels confident in assessing the strengths and weaknesses of the curriculum in a more objective manner.

In her final presentation Teacher B set out a comprehensive framework encompassing her experiences and what SMC entails. Teacher B‟s exposure to viewing the curriculum across the entire Grade R to Grade 3 has helped her see the rationale of teaching content within each specific grade. The SMC has taught her to consider the direction the students were taking in mathematics. She embraces the meaning of a curriculum extending beyond the basic syllabus. Should a more clearly defined spiral curriculum be developed within the South African curriculum, she felt it would assist teachers in comprehending the goals for teaching throughout the entire Foundation Phase.

She values the role of creative play and discovery using numbers in early childhood development. In the Grade R curriculum, the initial threat that the teachers would possibly have to forfeit playtime to impose a curriculum on the students did not materialise. She has experienced far more use of games and fun activities within her teaching practice by following the SMC. The specified time for mathematics in Grade R no longer presents a challenge. She wants to instil a wonder of discovering patterns in numbers. How Teacher B adapted the structured play within mathematics to do this was an enlightening experience for both the teacher and the students alike. Whilst working with the six-year-olds, her focus remains on the enjoyment of mathematics and confidence in using numbers in a variety of fun ways.

The introduction of different resources and a variety of tasks has alleviated any concerns she had about SMC. Teacher B reported that the students enjoy engaging in hands-on mathematical activities. The importance of appropriate questioning to enhance learning is an area where she feels she has personally changed her instructional approach using the SMC. The SMC has introduced more concepts to the Grade R curriculum and she is comfortable with the amount and level of concepts specified.

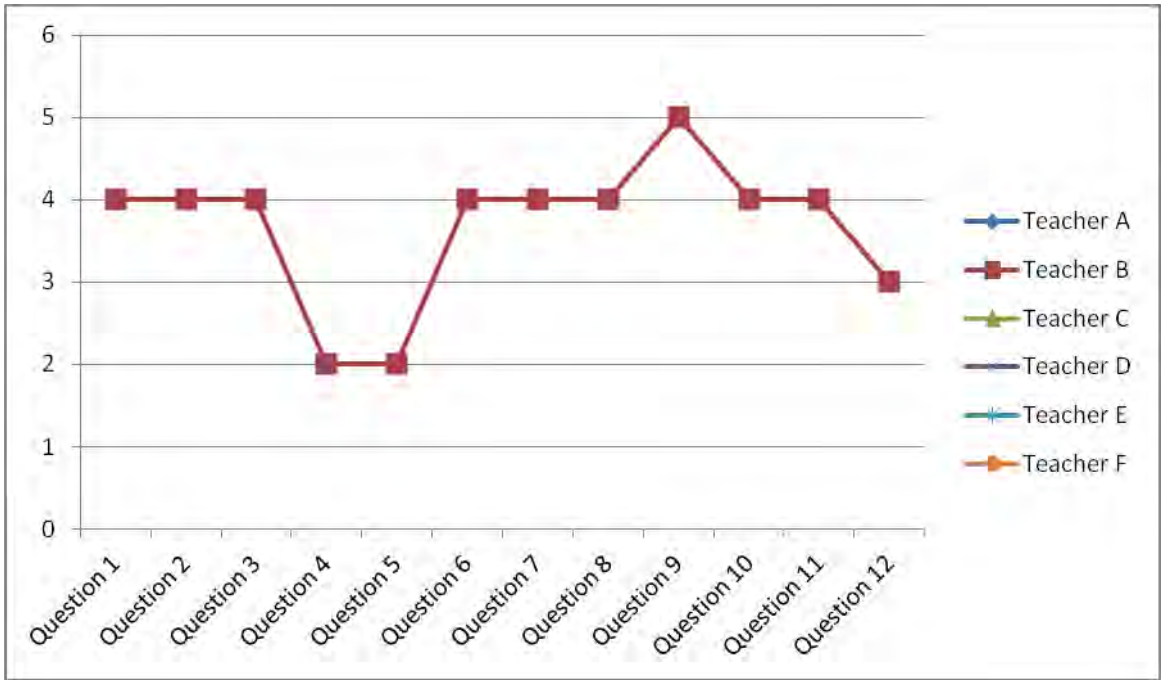
Teacher B appreciates the specific mathematics language introduced in SMC at this age. The fact that all teachers are talking and using the same vocabulary is brilliant in her opinion. This is particularly significant for the weaker children or those learning in English which is not their mother tongue.

Teacher B wrote favourably about the two student workbooks as a positive semi-concrete experience which the girls love. Following the use of concrete apparatus, the workbooks are helpful in reinforcing the learning that is taking place. She recalls positive feedback from the students who love the colourful pictures and readily engage in conversations about numbers.

4.2.2.4 Rating the SMC

Teacher B answered this section about the rating of SMC based on her experiences when teaching five to six year old students. She stressed the needs for lots of concrete apparatus when introducing concepts in mathematics. This included the use of a student‟s own body as a valuable resource. For her, how children come to know and understand number takes precedence over the correct product. She felt the workbooks don‟t allow for as much creativity as she would like, but conceded that the students love working in them. At Grade R level she has **not had many dealings with bonds and multiplication methods**, so practice and drill are not applicable to her grade. She finds the teaching of number formation repetitive, yet essential in the preparation of Grade R students for Grade 1.

Graph 4.2 shows how Teacher B rated the SMC as per the questionnaire (Appendix B)



Graph 4.2 Teacher B‟s rating of the SMC

4.2.3 Teacher C

4.2.3.1 Personal background

Teacher C is a mother of two school-going daughters. She qualified with a Bachelor in Primary Education and has taught in both the public and private school systems. She is married to a teacher and is in her mid-thirties. Both her parents are teachers and she has always taught within the East London area. Her favourite teaching subject is mathematics.

4.2.3.2 Personal beliefs and experiences

Teacher C started teaching at a school where her colleagues were very experienced, older teachers and established in their routines and practices. She admits to merely following their lead by fitting into the system without asking too many questions. With the implementation of the NCS curriculum in South Africa, she started to question teaching practice. She had moved to Grade 1 where as the youngest teacher she felt her questioning attitude was suppressed. She felt the students were working in a high number range too quickly. The pressure of learning mathematics at too fast a pace was compounded by the use of very little concrete apparatus.

A change of schools was a massive career move for her. She followed the RNCS where she took the initiative to question everything she taught or wanted to teach, experiencing a new-found freedom in her teaching. She questioned existing methods that did not make sense to her and became more critical and reflective of what she was teaching. She grappled with her view that students were still being forced into performing calculations in a particular way using rules and recipes. She felt mathematics in the classroom was far too abstract.

4.2.3.3 Teaching the Singapore Mathematics Curriculum

After changing schools, Teacher C was faced with the challenge of introducing a new mathematics curriculum at her school. She was extremely excited about the new approach, although she felt the training was inadequate. The new curriculum confirmed the problem that she felt she did not have appropriate or sufficient apparatus. In her opinion, the teacher who merely demonstrated concepts using concrete apparatus was insufficient and she acknowledged that initially she did the classroom concrete demonstrations. The semi-concrete step in the SMC afforded the students an opportunity to work from a textbook and then in their own workbook. Making use of a colourful and informative textbook was a totally new teaching experience for her. She found it challenging to teach fewer topics and had to convince herself that the curriculum was a long-term process where her role in Grade 2 was only a small section of the bigger picture. She no longer teaches in confined compartments and enjoys following a spiral curriculum. She believes that children must acquire their own knowledge in learning. This has resulted in Teacher C claiming to have moved away from teaching in a way where she considers herself as the primary source of all knowledge. She has gained new insights over the 3 years of teaching the SMC and acknowledges how her confidence has grown in teaching. As a teacher she believes her role is crucial in motivating and sharing a love of mathematics with students.

The change, from a quieter class with little discussion or peer interaction about maths, into an active engagement in discussions in class, was a highlight for her in the SMC. She no longer gives instructions from a chair, spending most of her time on the mat questioning for understanding and engaging with students about what they do and the possible reasons for their actions or thinking.

Her approach to mathematics has changed entirely. She says her original love for mathematics has been restored. She also regards herself as a student and applauds life-long learning. She is particularly excited with the **now I can see** of weak children. She is comfortable teaching in the number ranges as set down in the SMC and whilst following the curriculum, she is able to use her own initiative.

Most of her lessons start by using manipulatives [11] on the mat and the children work with apparatus to discover and learn new concepts. However, she feels once they understand a concept they should be allowed to work in the abstract. Observing each student work firstly in the concrete to try and solve a problem has been so enlightening for her. She reports how they try to solve a problem on their own and her role is to encourage and ask pertinent questions. All students have their own manipulatives to work with. Since the introduction of the SMC, resources have played an important role as they support the rationale of working in a 3 step approach. Using the SMC approach, she feels, allows and encourages all the children to share and discuss what they are doing. The fact that the whole class is working on the same activity allows for greater discussion and sharing of ideas. In particular she spoke about opportunities for students to discover and come to understand number concepts. The reward of weaker students who come to understand and **see for themselves** has been a gratifying experience for both the teacher and students. She has been able to provide tasks where students are actively engaging in solving a problem.

She values being part of a focus group and enjoys sharing and learning from other teachers and their teaching of the SMC. One of her goals in teaching is to turn weaknesses into opportunities. She has produced a practice book as she feels there is an insufficient amount of problem solving in Grade 2. This is because we use *My pals are here*, [12] Book 1A (Kheong et al., 2007a) in Grade 1 in South Africa and *My pals are here,* Book 1B (Kheong et al., 2007b) in Grade 2 in South African schools. In Singapore, when teaching the SMC, they combine both books in one year.

[11] Teacher C refers to manipulatives as physical objects used by students to represent any mathematic idea. Kilpatrick et al., (2001, p. 9) concur with this notion.

[12] "My pals are here" is the series of resource books available at each grade level

She has gained in confidence in teaching mathematics and **loves the creativity** within SMC mathematics lessons. The introduction of games and fun filled activities into her class has motivated her students. She reports the students are loving learning. Through the use of games, the SMC introduces abstract concepts at a deeper level in a non-threatening way. She marvelled at the level of understanding being developed through the playing of games and fun activities.

Having worked with the SMC for three years, Teacher C stressed the important role of language, stating it is vital to allow students an opportunity to explain, describe, reason and come up with their own answers and ways of expressing a solution. Without understanding the terms used in mathematics, there can be no meaning. Understanding concepts is as crucial to her as getting the answer correct.

4.2.3.4 Rating the SMC

Half of Teacher C"s ratings were in the negative, but she justified her rating with a comment in each instance. She strongly disagreed that formality and specific methodology take priority and stated there is **no provision for practice and drill** in the SMC. Teacher C would like to have more practice and drill of computations once they are fully understood. Hence she produced her own booklets for practising bonds and tables as stated in 4.2.3.3. Whilst logic plays an important role in mathematics, she felt it should not be at the expense of creativity and originality.

I took particular notice where Teacher C"s ratings scored at least two points lower than any of the other members of the focus group.

- In question 1 she disagreed with the teaching of mathematics according to a specific flow as per the manual. However her explanation stated, **Yes, the development of concepts is important but sometimes your own ideas are better in getting concepts across.**
- A second negative response was regarding the teaching of SMC in a three step approach, and was answered with the explanation: **Great for new concepts, but some children don't need all the steps for all concepts.** She added a proviso that they can work in the abstract.
- The third response which differed from the other members of the FG, referred to question 11 where she appeared to stress the importance of explaining verbally and not always on paper. For assessment purposes she reported that communicating one"s thoughts on paper was important.

- Whilst the majority of ratings were negative, the actual explanations and justification of statements revealed the teacher was actually quite positive about the SMC.

Graph 4.3 shows how Teacher C rated the SMC as per the questionnaire (Appendix B)

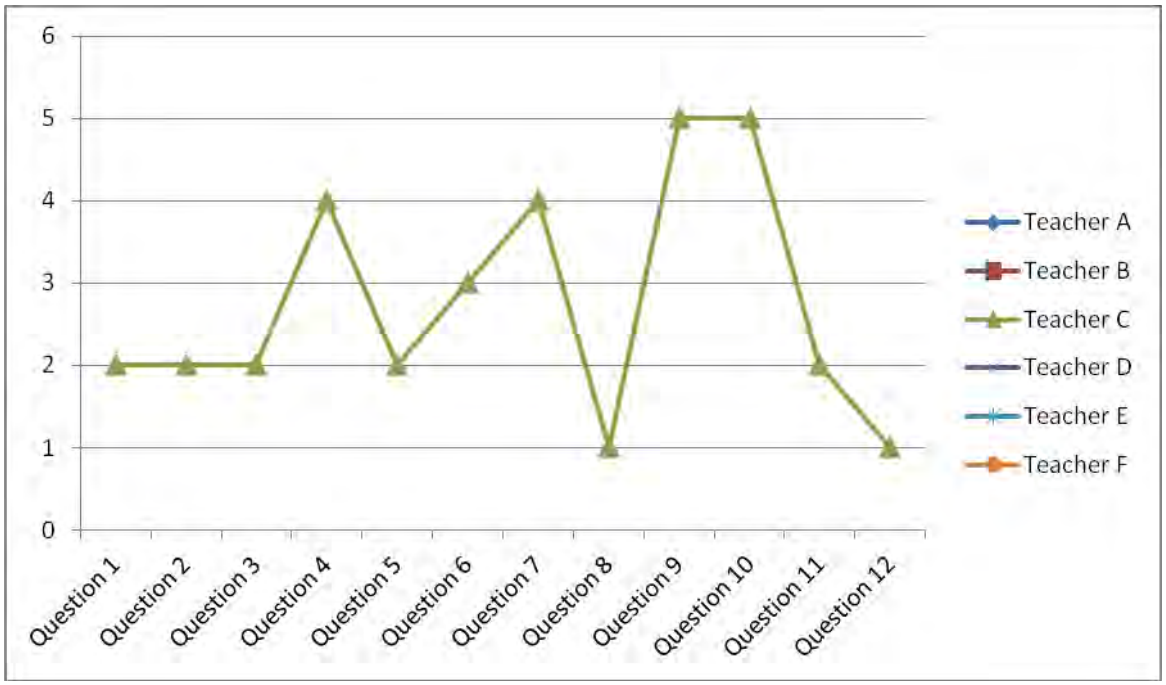


Figure 4.3 Teacher C‟s rating of the SMC

4.2.4 Teacher D

4.2.4.1 Personal background

Teacher D has 20 years of teaching experience across the grades and has taught in both single sex and co-educational schools in both the Western and Eastern Cape. She has held both departmental and school-funded posts and has strong convictions concerning teachers being remunerated adequately for the crucial role they play in educating the children of a nation. She holds a four year teacher qualification in the Foundation Phase of schooling and is currently a mother who has followed her daughter‟s growth in mathematical knowledge and is determined that she will not experience the negativity she herself endured as a student.

She shared her own fears of mathematics while at school where she had a negative attitude to mathematics stemming from bad experiences with teachers as far back as her primary years. This has made her determined to play a positive role in the lives of each little girl entrusted to her care. As a

single parent, her own daughter‟s success (nearing completion of her schooling career) has been a constant reminder to remain committed to addressing the real needs of young students in mathematics.

4.2.4.2 Personal beliefs and experiences

Despite feeling humiliation at the hands of a teacher when she was a student years ago, she is determined to boost students‟ confidence and help them become confident problem solvers She has taken the negative experiences of her past and used them to create a positive and encouraging environment for students in her class today. She believes the student‟s confidence and motivation to learn can be enhanced or destroyed by what a teacher does and says in the classroom. She concedes other factors are equally important in determining a student‟s attitude to learning mathematics.

She feels strongly that students should be able to discuss learning and share their thinking with peers in the class. Mathematics can be integrated into other learning areas in the Foundation Phase of schooling and Teacher D likes incidental learning of number throughout the school day. She takes her responsibility as a teacher very seriously and stated that she aims to make a positive difference in the lives of children wherever possible. She uses her experience as a mother to instil an appreciation for number and the importance of mathematics in the everyday life of every student in her class. She regards teaching as a noble profession and regards her responsibility to teach well as non-negotiable.

4.2.4.3 Teaching the Singapore Mathematics Curriculum

Teacher D is an extremely enthusiastic teacher who values professional development. She presented her experiences with a strong emphasis on the knowledge needed for teaching and the process of teaching mathematics where understanding is vitally important. The lessons, she explained, always allow children to work in the concrete and that self-discovery was stressed in Grade 1. She claimed this approach was not new to her when she was introduced to the SMC. Her change in belief using the SMC is that no child should avoid or be denied the opportunity to discover solutions for themselves. The logical flow of teaching concepts is important to her. Hands-on activities, and working in semi-concrete or pictorial form are crucial steps before students are introduced to the abstract concept. She observed from examples of children working in groups and in the workbook, that the need for understanding is important and feels that understanding is as crucial as following a procedure to secure a correct answer. She welcomes the absence of tricks and key clues in learning. The approach to solving problems and students coming up with their own solutions was captured on video. This

included activities where discovering, working and playing with numbers was demonstrated in various ways.

The SMC step by step logical progression in teaching does not stifle this teacher‟s own creative approach. She loves the logical approach to problem solving and yet she feels she has had the freedom to introduce additional fun and creative activities within the mathematics lesson. Teacher D refers to the spiral curriculum acknowledging that it calls for an understanding of concepts in a deeper way and not merely repeating the same concepts. SMC calls for building on prior knowledge and affording students opportunities to delve deeper into their understanding of concepts.

Regarding the students in her class, Teacher D advocates the need for appreciating diversity and different cultural influences within the classroom as espoused by Kilpatrick et al. (2001). She reinforces the principles of the theory of constructivism by sharing how children love to work constructively together in a reciprocal manner. She acknowledges that the knowledge that each student constructs has value attached and that is dependent on the social forces in a specific context. Referring to the Eastern Cape context, she embraces the rich diversity of students to enhance quality learning and teaching.

She concurs with the statement that "all teachers must learn to think mathematically and think mathematically to learn" (Kilpatrick et al., 2001, p. 6). In fact she took this statement further. Not only does she believe mathematics can be learned at any stage of life, but she also views the teacher as the role model for her students. She admits it is no small feat to be a good teacher and one has to adapt and embrace the changing world we live in with enthusiasm.

Her goal is to discourage negative experiences and allay fears while learning. The fear of not knowing how to work out an answer should be dispelled. Students should be encouraged to try and come up with solutions on their own as well as in a group. Regarding how to go about the business of teaching, Teacher D subscribes to the notion of scaffolding[13] and she feels that this helps her to scaffold the learning experience of students by using mechanisms such as, open-ended questions and resources to help children move from one stage of learning to another. Teacher D also views her role as one of co-

[13] Teacher D uses the term when she is helping and encouraging the student to engage with an activity whilst trying not to show them how to do it.

learner when embarking on a **joint project of learning and discovery** to acquire greater conceptual understanding and the acquisition of procedural fluency.

Her changed attitude towards mathematics means she has overcome her negative attitude and fear of failure which has been replaced with a sense of **I can do it.** She describes incidents from her own personal perspective as well as delightful stories of girls who discover the wonder and excitement of mathematics.

The role of language is vital in the teaching and learning for mathematical proficiency. If mother-tongue is different to the language of learning and teaching, it is a cause for concern. SMC encourages conversations amongst students and between teacher and student to explain solutions and strategies. In order to explain how they come up with an answer, the student needs the required language skills. Dealing with the correct terminology requires an understanding of the vocabulary in real terms. Teacher D shares the challenge of working with students who are disadvantaged by not having the communication skills to talk, express and explain what they are thinking and doing in maths. It is time consuming explaining the vocabulary to students whose mother tongue is not English. In South Africa at the start of Grade 1 the reading level of students is limited and the teacher is required to do a lot of reading in the SMC textbook. The whole class approach is used to streamline learning for all and saves time, but the weaker students need time to grasp a concept. By and large differentiated group teaching is not envisaged in the class lesson in the SMC. Group work and working in pairs is difficult with students who do not have the level of reading skills for the activity. It would, in Teacher D‟s opinion, make the amount of work in the curriculum too impractical to cover for the first six months of the year. This leads to frustration on the part of teacher and top achieving students become bored. Language barriers need to be supported as Teacher D sees mathematics as a language of its own.

Teacher D celebrates the part-part whole approach to teaching mathematics as a means to adding through the ten with understanding. She admitted to merely teaching a method or short cut in previous approaches to addition through the ten. This approach makes the commutative property in mathematics a discovery rather than a fact to be learnt. Here the teacher does not have to use the **adult talk** when children discover the sense of commutative property without talking about it. They see what is happening before they can express it clearly.

Teacher D supports the drill and practice of a concept once it has been understood. The absence of drill and practice in the SMC she regards as a weakness in SMC. She has come up with strategies and extra activities to address this problem. She does, however, concede that the more proficient students would prefer enrichment opportunities to repetition and drill.

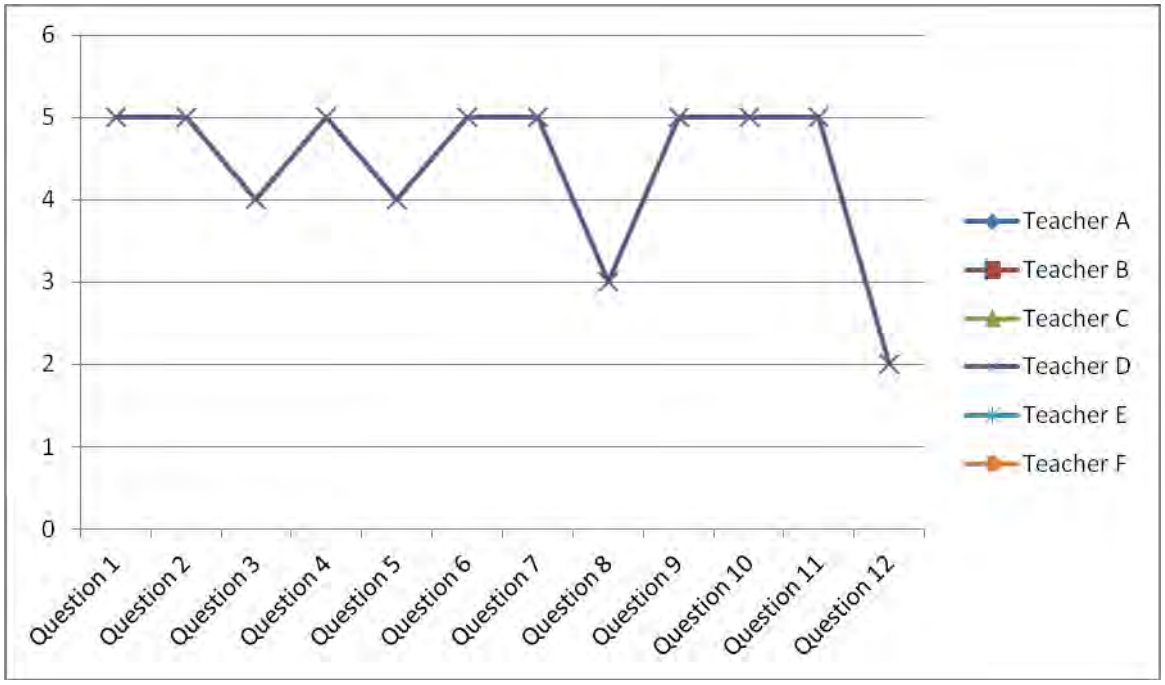
Teacher D also considers her role as one of co-learner when embarking on a joint project of learning and discovery to acquire greater conceptual understanding and the acquisition of procedural fluency.

The view of the teacher as a reflective practitioner deals with how teachers reflect on their own practice and what they actually do with the SMC. This teacher felt empowered by the use of SMC. She now has a structured, well-planned curriculum that flows and develops accurately and provides guidelines and tips to help her in her teaching practice. The role of manipulatives is essential in all lessons.

4.2.4.4 Rating of SMC

It became evident that Teacher D rated the SMC highly and her concern regarding insufficient place for practice and drill in SMC was the only negative rating noted. She added pertinent comments in response to the questionnaire and strongly agreed with how teaching mathematics provides an excellent opportunity to promote the development of the pupil"s thinking and added it also serves as an excellent opportunity to develop, explore, explain and reflect. She felt that problem solving should always be at the core of teaching mathematics, adding that finding a solution or strategy was also core to the SMC. Whilst Teacher D acknowledged that the SMC views communication as important both verbally and in the written form, she mentioned time constraints as a factor to be considered.

Graph 4.4 shows how Teacher D rated the SMC as per the questionnaire (Appendix B)



4.2.5 Teacher E

4.2.5.1 Personal background

Teacher E qualified as an Intermediate Phase school teacher and began her teaching career in a Grade 4 co-educational school. After four years of studying towards a degree in education, she realised that her own teaching style was better suited to younger children and applied to teach in a Grade 3 post. She is a committed teacher and assumed a leadership role with the implementation of the SMC. She sees the potential of an alternative curriculum to enhance students understanding of number. She has the personal challenge of trying to balance her role as a mother of a baby born in 2011 and the return to the classroom as a teacher. Striking this balance is not easy. Time management is a challenge and numerous personal constraints are a reality in her day-to-day teaching.

4.2.5.2 Personal beliefs and experiences

Teacher E explained that her own school learning had been grounded in a very behaviourist approach to teaching. Teaching and learning was done with little apparatus and little understanding. She had rules and procedures drilled into her. Her learning experience in mathematics was characterised by rote learning. This was not a positive experience and maths was seen as a subject to learn by the rules and then apply them when working out the answers. She recalled how her own personal experiences as a student at school were marred by having to learn tricks and rules. She became disheartened by teachers telling her to stop asking questions when she didn‟t understand.

She feels mathematics teaching should make use of real life experiences and take account of prior knowledge. She stated that concepts and skills should be learnt through the use of manipulatives at a concrete level. She regards the teachers‟ role as being a facilitator to learning and that ideas need to be shared and discussed. She acknowledges that **students need to think for themselves and be allowed to mull over what they are learning.** She declared that time and timing is so important.

She firmly believes that **language plays a huge role** in learning and making meaning of number sense. She struggled with new concepts while at school and feels this was due to a lack of communication in the mathematics lessons. In fact students were discouraged from asking questions. She feels communication makes the difference in the classrooms today. Teachers motivate and encourage students communicating their expectations for success. She feels it is the teachers‟ responsibility to ensure understanding takes place in the class. Building up the self esteem and sense of worth in a child, can alter a negative attitude to mathematics.

She enjoys teaching mathematics, but admits that to teach well involves a lot of work and planning. Her conviction is that learning procedures without conceptual understanding hampers the possible success of a student in mathematics. The emphasis on conceptual understanding and procedural fluency going hand-in-hand and being of equal importance makes **absolute sense** to her. It is the teacher‟s responsibility to ensure students understand mathematics.

4.2.5.3 Teaching the Singapore Mathematics Curriculum

The role of language had a huge impact on her teaching whilst using the SMC as through discussion, she saw how meaningful the learning can be for the students. Her role is to encourage students to think for themselves and come to understand what they are doing with numbers to make sense of the relationship between numbers.

She has thoroughly enjoyed the introduction of the “model method” into her Grade 3 class. This new approach to solving problems and trying out the model method using strips of paper to estimate the bigger numbers, has been a very rewarding teaching experience for her. Her initial scepticism about the students‟ ability has been defused as their understanding of the model method is rewarded by their ability to work out problems sensibly and accurately plus they can explain the rationale behind their solutions. Working in pairs or small groups has afforded the teacher the opportunity to observe how the students assess their peers‟ work through conversations. Their interaction makes it possible for the

teacher to listen to their reasoning and explanations to one another in a way that she feels teachers sometimes can't put across.

Whilst she uses a variety of assessment tools, she acknowledges the importance of communication in allowing students to verbally explain their thinking and reasoning. Using the model method in problem solving also presents a visual representation of how students communicate their thoughts on paper. She felt that using SMC she was using peer and self assessment more frequently in day-to-day learning in a non threatening way.

I observed Teacher E helping students make sense of mathematics. The video recording of the classroom tasks indicate that conceptual understanding and procedural fluency feature more strongly than the other three strands of mathematical proficiency (Kilpatrick et al., 2001). Mathematical problem solving was central to mathematics learning in the lessons observed and the belief in students to develop and explore their ideas in depth was evident. As the students were able to connect different ideas and gain new meaning to solving problems, they learnt to gain new skills and new understanding in learning. The teacher stated that this resulted in greater confidence in the students and a determination to explore possibilities to come up with solutions.

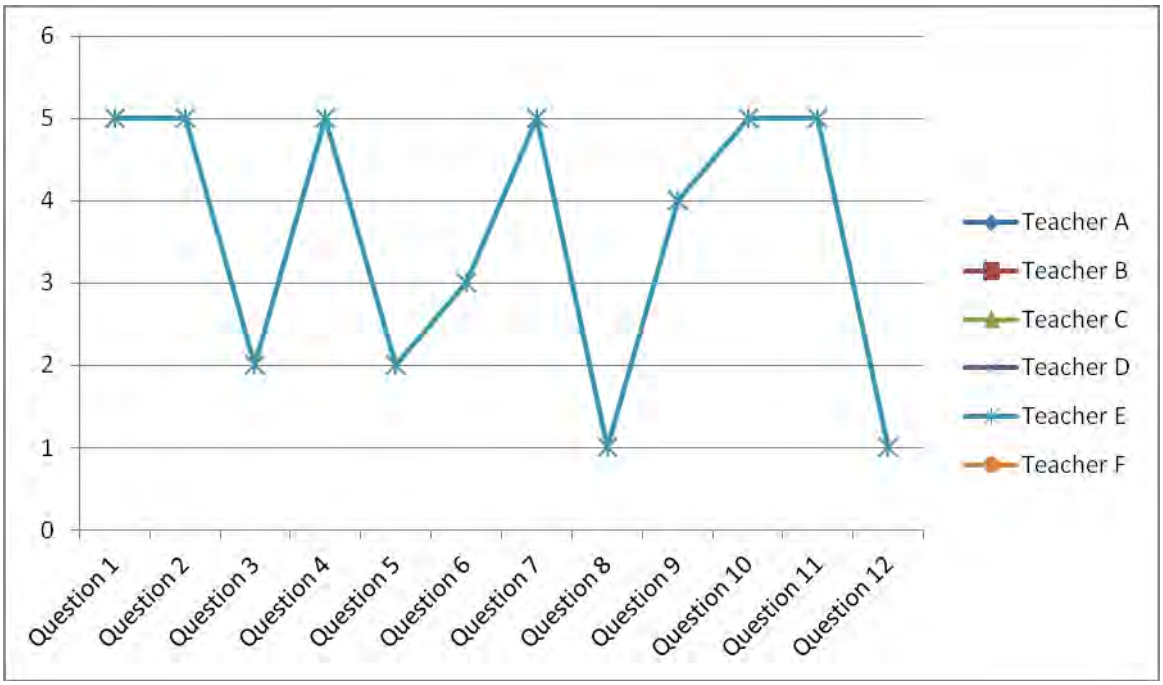
Teacher E felt that the explicit games and activities provided in the SMC allow for and promote creativity. She called for the supplementation of drill and practice exercises although she stressed that understanding is more important than just getting the answer correct.

4.2.5.4 Rating the SMC

Teacher E voiced her strong disagreement regarding formality and specific methodology taking priority in the SMC. Her response explained her reasoning: **NO! Students must find their own solutions that display their understanding.** She does not feel that logic is promoted at the expense of creativity and originality. She feels that the manuals allow for creativity and provides worthwhile games and activities. Whilst rating question 5 at a level of 2 shows disagreement to the process and correct product being equally important, Teacher E explains that one must get the answer correct, **but understanding the process is more important.** Clearly Teacher E places a lot of emphasis on the SMC that allows for students to explore and grasp their own mathematical ideas in order to develop a deep understanding of mathematical concepts.

As a Grade 3 teacher, Teacher E commented on the lack of sufficient drill and practice in the SMC referring in particular to bonds and tables which need to be supplemented in class time.

Graph 4.5 shows how Teacher E rated the SMC as per the questionnaire (Appendix B)



Graph 4.5 Teacher E"s rating of the SMC

4.2.6 Teacher F

4.2.6.1 Personal background of teacher F

Teacher F is an experienced mathematics teacher having taught at all Foundation levels. For the past 10 years she has taught in Grade 3 at both private and government schools. She holds a Higher Diploma in Education and whilst her love for mathematics started while she was a student she was disheartened when teachers told her that she asked too many questions in high school. Her passion for maths ensures that she teaches her students to think about what they are doing in mathematics. She strives to instil a passion for numbers with the students and she values an enquiring mind.

4.2.6.1 Personal beliefs and experiences

Teacher F regards the mathematical knowledge of a teacher as crucial and feels strongly that teachers must be able to do and understand a number concept before teaching it. She aspires to understanding how children gain an awareness of how to "do maths" to make sense of the world in which they live. Her view is that Mathematics is art in numbers. She believes the best way to learn is to experience,

think, act and discover a fascinating world together with others. She espouses that mathematics continually develops for each explorer. She strives to instil a passion for learning and stated that **it is very rewarding when students catch mathematics and beg for more!**

As a scholar she tried to understand all the rules and formulae in a maths lesson. Now her goal is to allow students the opportunity to grasp concepts and not just accept what they are shown or taught. She believes the problem-solving approach to mathematics is a core element of successful teaching of mathematics. Her conviction is that children must ask questions for greater understanding. The appreciation of higher order thinking skills is evident in how she poses questions as a teacher in her class.

When observing a lesson it became apparent that all children were enjoying being actively engaged in their own learning and in the tasks presented to them. Another key observation was the attitude of the students when engaging with more challenging problems. The SMC encourages students to persevere. Teacher F welcomed the acknowledgement of a curriculum endorsing a positive attitude. She shared her concern of a particular mathematics programme no longer used at the school which created, in her opinion, unnecessary anxiety amongst some of her students.

Using questions to probe approaches to problems, she encourages students to find a solution that makes sense to them. She also allows the sharing of different methods and strategies among the students which shows she values co-operative learning and appreciates the worth of each student. The questions posed afforded the students the opportunity to be cognitively challenged and persuaded them to think and reason in different ways. She encourages children to come up with at least one way to think about and justify their solutions.

4.2.6.3 Teaching the Singapore Mathematics Curriculum

As a teacher who admits to questioning and reflecting on the processes of teaching and learning, Teacher F regards the SMC approach as a success in her class. Based on her years of experience she regards some of the methodology as too prescriptive. She believes in catering for alternate methodologies and finds support from those in charge of curriculum at her school. Her flexible approach which exposes students to various strategies and ways of working things out and actually doing maths, reflects her belief that maths is a creative art and solutions need to be “discovered”.

At Grade 3 level, much debate within the focus group was on the algebraic (Solution B less stressed in SMC) or the algorithmic way (Solution A) of working with a sum e.g. 13 x 21

Solution A

```
   H T U
     1 3
     2 1
     1 3
+  2 6 0
   2 7 3
```

Solution B

X	10	3
20	200	60
1	10	3

200 + 60 + 10 + 3 = 273

Teacher F feels it is a pity that a specific methodology, particularly in long multiplication and division is emphasised. Appreciating the spiral curriculum of the SMC, she acknowledges that the rationale for a certain methodology is to arrive at the most efficient and economical way of solving a problem. This supports her view that original thought and creative solving of problems needs to be explored and that it is the teacher"s responsibility to ensure opportunities for self-discovery are encouraged within a maths lesson. She concedes the formality and specific methodology that occurs in the SMC is always with understanding, but alludes to the fact that different approaches could receive more attention. As Teacher F explained, she would like to introduce algebraic way of thinking well before they are expected to be proficient in manipulating algebraic symbols. This notion is fully supported by Kilpatrick et al. (2001).

She supports **the 3 step approach absolutely** and stresses the importance of teaching mathematics using the concrete, semi-concrete or pictorial and then the abstract in all teaching and learning. She stressed the value of the SMC recommended resources in her teaching. She feels creative resources abound and all children should be expected to work with manipulatives. The students who prefer to call out a solution after thinking about the answer are encouraged to present their solution in pictorial form. Teacher F presents more cognitively challenging tasks to students who enjoy working in the abstract.

Teacher F deviates from the actual Singapore approach from a creative point of view. Her solid pedagogy makes her confident to teach mathematics and she sees the logic of working with numbers as a life necessity for all students in her class. The tasks she sets students have a fun, "hands-on" approach and this is what she enjoys about the SMC supporting her belief that maths is fun and games play a big role in learning and making sense of numbers.

Referring to the relationship between the teacher, her class and the maths content, she feels that the knowledge of each learner and his or her needs is an important part of the teaching of mathematics and her focus within the SMC is to allow each child the opportunity to learn to use his or her own methods and ways of discovering with the teacher guiding their thinking and setting appropriate tasks for the individual child.

The spiral curriculum and the notion of maths as a fun process which flows from one concept to another is important for each student to learn mathematics in a logical way. A focal point of her presentation dealt with the teacher as a role model in demonstrating and using the correct and accurate terminology and language in mathematics was. Factors, trapeziums and the product of 2 numbers are the appropriate mathematics vocabulary and terminology used in Grade 3.

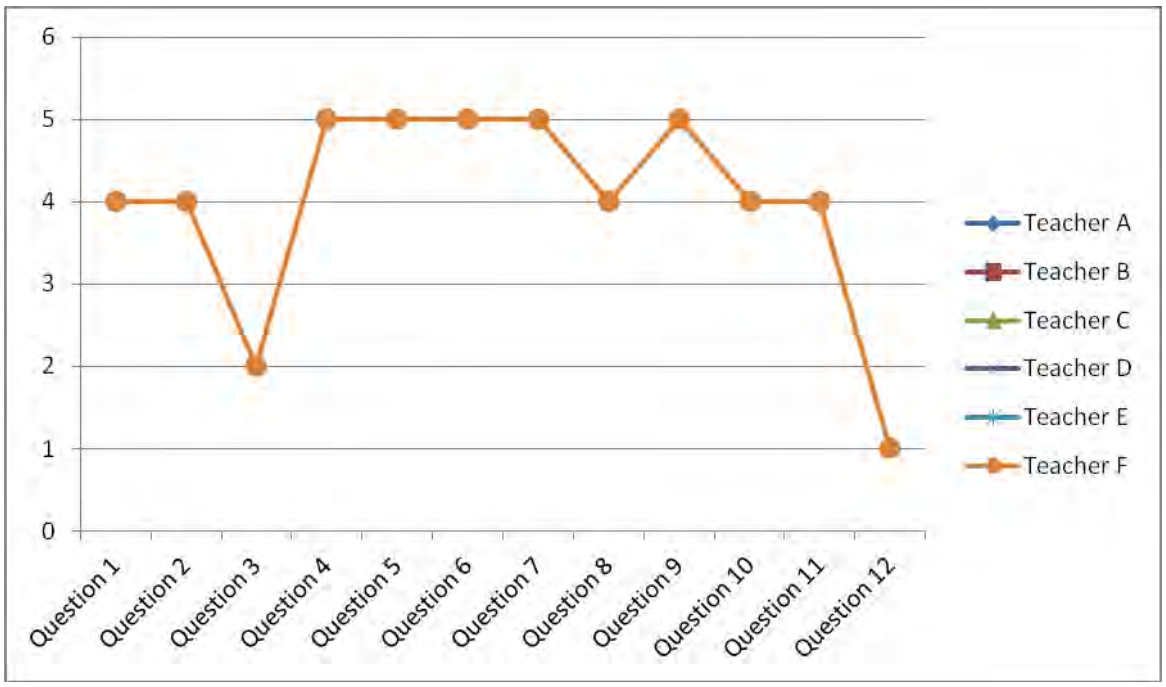
Within the teaching of maths, she refers to the relationship between the teacher, her class individual learners and the maths content. (Instruction triangle) The knowledge of each learner and their needs is an important part of the teaching of mathematics and her focus within the SMC is to allow each child the opportunity to learn using his or her own methods and ways of discovering where the teacher guides their thinking and sets appropriate tasks as per the individual child.

From the individual student learning maths in a logical way, she describes the importance of the spiral curriculum and the notion of mathematics as a fun process which flows from one concept to another. Teacher F feels that the flow of a lesson must ensure that **foundations are suitably covered before building on them.**

4.2.6.4. Rating of SMC

Teacher F stated "absolutely" that mathematics teaching and learning requires the use of a concrete-pictorial-abstract approach to all learning, but she added that a student who has grasped a concept and can solve problems abstractly, should "not be forced to represent it pictorially every time". She felt that allowance is made for originality, but not enough in some areas of instruction. Logic is important to her as she rates it in the SMC. However she said it is a pity that in some areas, for example long multiplication and division, that specific methodology takes priority over logical reasoning.

Graph 4.6 shows how Teacher F rated the SMC as per the questionnaire (Appendix B)



Graph 4.6 Teacher F‟s rating of the SMC

4.3 PHASE 2: WORKSHOPS AND FOCUS GROUP DISCUSSIONS

The second phase of data collection was collected through collaborative focus group sessions in the format of either workshops or discussion amongst members of the group. The apparent change of attitude of some teachers and how they openly shared in the journals provided me with a lot of rich data to work with. The teachers‟ voice could also be “heard” regarding frustrations and constraints within daily practice, whilst delightful moments of reward for meaningful teaching were also able to be recorded.

Generally these meetings were to observe and discuss video recorded lessons. As the teachers talked to each other, their conversations were captured on video recordings. The tension or disagreement they may have experienced relating to their previous teaching practice versus the current use of the SMC is also of significance. The discussions and findings from experiences shared collaboratively in the focus group workshops and meetings afforded each member an opportunity to share her experiences.

The categorisation of data into themes emerged from the discussions. From the collaborative discussions amongst the focus group I was able to draw out common themes which emerged from the conversations and from video recordings of group discussions. These are covered in six themes and

are specifically referred to in 4.3.3. They were:

1. The role of the teacher and the knowledge required for teaching;
2. Professional Development, training and support for curriculum change;
3. SMC and the role of language;
4. Hands-on activities and manipulatives;
5. Student learning and learning methodology, and
6. Attitudes towards the teaching of the SMC.

4.3.1 The first workshop

At the initial meeting with the teachers, minutes were taken and this workshop was to provide information to all participants of the envisaged research project. It afforded the participants an opportunity to raise questions and we discussed a negotiated set of ground rules and expectations. Thereafter, the workshops were of a different nature as all participants developed a collaborative relationship and were willing to share their experiences and concerns openly in a group where they felt comfortable. Respecting others teachers viewpoints, they felt confident to share openly in this forum. It had been decided upfront that the final focus group meeting would be where each teacher made her final presentation. No formal data was collected in this first workshop as it served as an orientation workshop. The minutes of this workshop are attached as Appendix G.

4.3.2 The second workshop

Apart from reflections recorded in the teachers‟ journal after the workshop no other formal data was generated during this workshop as it was interactive where teachers could ask questions for clarity about the process. During this workshop teachers were presented with supportive material including a checklist for teaching for mathematical proficiency (Appendix H). Some of their reflections after this workshop were written up in the teacher journals. Incidental times to share with members of the FG informally occurred throughout the study. This was an informal way of teachers being able to express their experiences particularly where they wanted comment on feedback. This was in line with the understanding that what they had shared I could write up as research and present to them as feedback for growth potential and also for validity of the data.

4.3.3 Focus Group discussions around video recordings of lessons

The focus group meetings were held in August, September and November of 2010 and again in February 2011. The meetings provided a forum where the teachers could openly discuss aspects of their teaching the SMC. On 4 March 2011the focus group convened to discuss extracts of the video lessons from both schools. I was also able to capture their ideas and thoughts during this discussion on video. All participants developed a collaborative disposition and were willing to share their experiences and concerns openly in this group. Respecting each teacher‟s viewpoint, they felt confident to share openly in this forum. To assist the teachers in their observations and reflections in their own practice, a framework for teaching for mathematical proficiency had initially been provided (Appendix A). These points helped them share what supports or inhibits teaching for proficiency. The discussions around the five strands of mathematical proficiency and using this framework as a lens to analyse the SMC led to numerous themes coming to the fore. The teachers noted with delight how some students were responding to instruction not previously covered and felt new approaches were working well. The topic of students‟ achievement in solving problems and being able to work out their own answers correctly indicated a growth in confidence.

The video-recorded mathematics lessons at both schools provided a wonderful tool for discussion at the focus group meeting. The extracts of video-recordings used in the focus group discussions were twofold. Not only could teachers observe the actual SMC teaching practice of colleagues taking place in a classroom at both of the two selected schools, but it also served as a mirror lesson within the focus group for discussion and reflection. The focus group conversations and observations shared were based on sections of the specific recordings and all comments were also video-recorded.

I now present the discussion of the focus group using a framework of themes that emerged. The analysis of teacher‟s personal interviews, journals, lesson observations, questionnaires, focus group sessions and the final presentation workshops resulted in six themes that emerged. The themes were identified and articulated in ways that promote or inhibit teaching for mathematical proficiency against the backdrop of the SMC

4.3.3 .1 Theme 1: The role of the teacher and the knowledge required for teaching

From the outset, the role of the teacher and her position concerning mathematics education was crucial. As the teachers were focussing on their own experiences, this was the first theme to emerge. I

acknowledge that the role a teachers plays in enacting the curriculum and what is understood by a teacher‟s own knowledge base is of significance to this case study.

The teachers‟ own lack of mathematical knowledge was deemed an inhibiting factor when teachers A, D and E shared how they had not previously had sufficient conceptual understanding when being taught and that the rote learning of rules and procedures denied them fluency in carrying out procedural skills in an efficient way. They realised the importance of reasoning in problem solving and Teacher F claimed that the teacher needs to have greater knowledge for teaching at a deeper understanding. One sentiment which was shared by all FG members was the notion that a teacher should have mathematical understanding to teach mathematics. By understanding mathematics, this term incorporated the what, when why and how to teach mathematics. A profound understanding of fundamental mathematics will allow you to question and set appropriate tasks for your students. To interweave whom you are teaching and the knowledge you are teaching is very complicated. (Ma, 1999). How the teacher adapts to cater for the different levels of understanding that students have will be dependent upon their strategic competencies. The adaptive reasoning of the teacher allows the opportunities for referring to prior knowledge and asking logical questions as to why the answer is right or wrong. Implementing a new curriculum raised the question of knowing and understanding the written curriculum and realising the role of the teacher in implementing it.

Teaching the basic mathematical knowledge to a young child in the early stages of schooling is crucial. Teacher B stressed the practical approach to learning and the understanding of discovering of concepts as essential to the teachers‟ understanding of this age group. Teacher E shared how she regards the greatest challenge facing the success of the SMC is the lack of teacher understanding of the curriculum. Embracing the SMC as a spiral curriculum will enhance learning if the teacher understands the importance of building upon prior knowledge to mastery and not just repeating the same concepts at the same cognitive level. Knowing and understanding what concepts have been covered in the previous year of learning is a prerequisite. Knowing to what depth is deemed acceptable is the teachers‟ responsibility in the SMC and crucial for all teachers to grasp. The difficulty of having pedagogical content knowledge (PCK) to deal with the actual teaching and how to come up with story sums that will appreciate the actual concepts in the learning programme is no small feat. Teachers acknowledged the difficulty encountered in selecting tasks on appropriate cognitive levels. All too often we fail to raise the expectations of the students or realise their potential by selecting inappropriate tasks.

All FG members acknowledge that with greater mathematical knowledge and understanding, came a greater confidence in teaching and teaching for proficiency. The content knowledge of mathematics was never assessed during this research process. The majority of the FG admitted that they were only confident to teach at the Foundation Phase level of mathematics. Whilst two of the teachers had either been trained in Intermediate Phase teaching or actually taught beyond Grade 3, the curriculum was contained to a large degree at the formative years of teaching and learning.

Each teacher had different views on her role as a teacher. All acknowledged the importance of the teacher, but teacher B and F in particular, see the opportunities that a teacher provides for students to self discover and express their understanding as particularly important. The teacher‟s instructional procedures were considered as against merely planning what "content" to teach.

Teacher A had introduced a lot more questioning in the course of her instructional practice and has opened up many lessons to discussion and listening to the answers of students. Teacher C regarded her role as that of a facilitator; one who helps students get to own their own understanding. This role differs from the teacher telling and sharing her own views and ideas. The call for a change in teaching focus is commonly acknowledged by all members of the FG. The new approach is perceived to place greater emphasis on the teacher asking questions and providing guidance to students as they construct and make sense of their own meaning of number. Teacher F alludes to the successful teacher as one who continually strives to find the right path to open the doors to understanding and she strives for all her students to achieve mathematical proficiency.

Teacher D acknowledges that the SMC promotes or encourages teachers to be more open to sharing their failures, misconceptions or lack of understanding and the areas in which they need to improve in their teaching of mathematics.

The teachers in the focus group were encouraged predominantly through the use of journal writing to become reflective practitioners. Asking them to record what had or had not worked after a lesson had instilled in some of the group a greater awareness of the value of reflection. Merely thinking without recording decisive actions was predominantly the way teachers operate. Considering if they had actually taught according to their new found understanding or merely reverted to some old habits was a thought provoking rhetoric question. Considering possible disagreement or tension between the SMC

and the traditional approach to only group teaching in mathematics lessons raised the contentious issue of pedagogical content knowledge required for teaching for mathematical proficiency.

Teacher C regarded her role as that of a facilitator; one who helps students get to own their own understanding. This role differs from the teacher telling and sharing her own views and ideas. The change in approach to teaching moves from telling to asking questions and providing guidance to students as they construct and make sense of their own meaning of number. The confidence and sometimes lack of confidence of teachers, was noted and all agreed a positive attitude impacted on the students. The motivating and supporting of students to build confidence in their abilities, was deemed essential in enhancing the students‟ potential to learn. Teacher C shared that the implementation of the SMC had afforded her the opportunity to reflect on her own practice continually.

4.3.3.2 Theme 2: Professional Development, training and support for curriculum change

Members of the FG value professional development and aspired to improve their practice. All the teachers referred to their schools as well-resourced and that professional development was readily available. However it was deemed that the attendance at a workshop or conference was only one small aspect of growing professionally and they appreciated that this did not occur in the majority of schools.

Coming to terms with the components of mathematical proficiency (MP) as espoused by the SMC, reaffirmed the importance of professional growth and the need for teachers to grow in their knowledge base. It was the general consensus of the FG that teacher development should be compulsory and ongoing. Teacher E shared how a weekend seminar on number sense in accordance with the five strands of MP had helped her as a teacher see the vital need of all teachers not only to understand mathematics for themselves but that it was equally important for all students to gain conceptual understanding. Teacher A relished the opportunity to be trained in Gauteng according to the SMC and her confidence as a teacher was restored as she successfully grasped and calculated answers correctly according to the model method. Teacher C was disillusioned by the inadequate training her school received in the SMC. All teachers recommend ongoing training and link it to support systems for teachers when implementing a new curriculum.

- Parent training

The mere fact that all students using the SMC take home a homework book each day alludes to the fact that parents were better informed on a daily basis as to the mathematics being learnt at school.

However, reporting to parents on a quarterly basis as prescribed by the SA DOE, is problematic when piloting the SMC. At times the reporting to parents results in the two curricula appearing to be in conflict. Rather than a shallow covering of topics for a day or week, the SMC delves into deeper levels of certain concepts limiting all the areas needing to be assessed in a specific term. As the SMC is being piloted, it is one consideration that causes some frustration as described by teacher D. Teacher D had valued the workshops held for parents at school B to inform parents of the rationale for the SMC. They had proved to be informative and appreciated by approximately two hundred parents who attended. Teacher D has grown in confidence in her knowledge of the SMC and as a result of her enthusiasm, she has offered to hold grade meetings for parents in the future.

Parents wanting to support their child‟s learning will need to be informed of the mathematics vocabulary used in the SMC. Addition and subtraction through the ten is termed “with regrouping” and not the generally accepted South African term of “borrowing from the ten”. The strategies including the model method to solve problems are unfamiliar to parents and training would be most beneficial for parents.

- The deprofessionalisation of teaching

Of extreme concern to the FG members was the lack of allocated time for teachers to have specific time set aside, apart from their administrative duties, where they could collaboratively develop and grow in their knowledge of teaching. Acknowledging that we live in a dynamic world, the responsibility of the teaching profession should be to embrace change and focus on education for the future needs of the students. The concept of being a reflective practitioner is not built into the psyche of a South African teacher and time constraints and time management were deemed huge constraints in this regard. A call to take cognisance of professional development and quality in-service training was called for.

4.3.3.3 SMC and the role of language

Understanding mathematics vocabulary and the role of language was discussed as a key component to success. As Teacher E exclaimed **the language is huge in mathematics**. In fact, Teacher D stated it was a language all on its own and the vocabulary needed to be clearly understood. Teacher B had appreciated the uniformity and agreement of the correct use of terminology in the SMC. It is of benefit to all students that the teachers talk the same “maths talk” and don‟t confuse the students with

unfamiliar words. Teacher D felt the accurate referral to the regrouping of a ten is an excellent example of clarity for students using the SMC. Teacher D welcomes the discontinuation of the false use of the word borrowing in subtraction through the ten. The implication for her is that the borrower has the intention of returning what they have taken.

4.3.3.4 Hands-on activities and manipulatives

More resources and creating new manipulatives strongly supported the SMC implementation. This includes the playing of games and fun activities. The use of resources including concrete apparatus, quality textbooks and workbooks in SMC can and will enhance learning according to the FG. Resources provide opportunities for greater understanding when doing and working in the concrete. By discovering number sense through the handling of concrete apparatus, the fluency with which children carry out procedural tasks can be enhanced. Explanations and coming up with ways of creating your own method promotes strategic competence from an early age.

The consideration that quality resources could prove costly and deemed out of the reach of the majority of the schools in South Africa was raised. Whilst the textbook, work book and homework are all aligned and systematically cover the same concepts, the apparent limited amount of consolidation for certain concepts was a cause for concern. The use of expensive ICT equipment needed to be presented in an interactive way where students do not merely remain passive and the teacher manipulates the "tools". The FG members expressed appreciation at the privilege of having access to wonderful resources and all agreed that it was a contributing factor to supporting students in their quest to understand and discover number sense. The SMC promotes the teacher as an extremely crucial human resource and the manuals were a helpful and resourceful aid.

4.3.3.5 Student learning and learning methodology

Visualisation is an important stage for the development of number concept. Children in their development reach a stage where they can recognise figures based on their appearance alone. A Foundation Phase student learns to sort physical shapes based on what they look like. As they develop their understanding, they learn to describe the criteria for what makes the shape. They are then able to recognise and name the properties of different shapes (Van Hiele. 1959). The use of the model method in the SMC, particularly at the Grade 3 level, has afforded children a strategic way of solving problems

through visualising and drawing the problem to find the solution in a new way. As teacher E and F explained, students are able to solve more challenging problems using this method. Teacher A having taught both in Grade R and Grade 2 is delighted with the hands-on approach to practical mathematics and related to the topic of measurement where she marvelled at the progression of depth of understanding over a two year period. However, the concern for the weaker children was noted as Teacher C felt that students who memorise facts or procedures without understanding often are not sure when or how to use what they know and such learning is often quite fragile. Here the need for smaller groups to "re-teach" concepts not grasped was called for.

Special features of the SMC were extrapolated and Teacher D claimed that undoubtedly, the part-part whole approach to teaching incorporating hands-on activities and the use of manipulatives has been a highlight for many of the teachers. Particularly in Grade 1 where she teaches, it has brought about a whole new meaning to the learning of concepts in Foundation Phase and is not just for the benefit of the weaker students.

Concern for the weaker students was raised as a result of the change from differentiated group teaching to teaching the class as a whole. The re-teach approach as a normal teaching practice in Singapore, calls for the minority who need extra instruction to be catered for by support staff. Differentiated teaching is still a norm in the Foundation Phase as per the CAPS document. (SA, DOBE, 2011). Providing students with their own textbook and letting every child in the class do some exercises together is challenging in Grade 1. This is because the textbook is reliant on a level of reading which the South African students do not have in the first half of the Grade 1 year. Classroom management is a challenge for the Grade 1 teachers, especially if some of the Grade 1 students can‟t read at the appropriate level of the textbook. In Grade 3 the teachers felt that the rich whole class discussions and co-operative learning strategies had compensated for class teaching and reported that re-teaching still allowed for group teaching and sometimes one on one discussion.

- Drill and practice

A concern raised by many teachers is that there is insufficient consolidation and revision in the workbooks. Both teacher A, C and D have implemented additional booklets to provide further revision for the students needing more practice, or for all the class as an activity when re-teaching some of the weaker students in a separate group. The teachers reported that there is insufficient practice and drill for concepts after the lesson. Although examples were presented in the workbook and homework

books, the exercises were deemed insufficient. The additional workbook compiled by Teacher C was readily shared with Teacher A and both concurred that it had been a positive and necessary supplement to the SMC in Grade 2 specifically. The Grade 3 availability of the "re-teach"[14] workbooks was reviewed in a positive light as it revised concepts in appropriate ways to aid consolidation.

The SMC focuses on depth of student understanding of mathematical concepts instead of memorisation of rules. Singapore‟s texts do not labour on students‟ time being wasted by having them invent inefficient strategies. In fact, Singapore‟s bar modelling technique is a technique that allows students to understand the mathematics of the problem and obtain the correct answer, rather than using trial and error (Garelick, 2006).

4.3.3.6 Attitudes towards the teaching of the SMC

Attitudes of both the teacher and student enhance or inhibit learning. In the lesson observations, the responses and reactions appeared to be affected by the personal attitude of the individual teacher. In analysing the responses to the questionnaire regarding each teacher‟s beliefs, I had looked at the individual ratings to determine how strongly they felt about components of teaching mathematics that were aligned to the SMC.

I noted how the positive disposition of teachers was fundamental to successful learning. The teachers who motivated and encouraged students help them build confidence in their own abilities. Teachers supporting and engaging all students enhanced the potential of the individual to learn. Teacher C shared that the implementation of the SMC had afforded her the opportunity to reflect on her own attitude to students. In particular, her attitude towards the weaker learner had changed. Believing the weaker children could become more proficient in mathematics, she reported on how these students had shown greater confidence and excitement when doing mathematics. Teacher D acknowledges that the SMC promotes or encourages teachers to be more open to sharing their failures, misconceptions or lack of understanding and the areas in which they need to improve in their teaching of mathematics.

A frustration shared by teacher A was that she was working with teachers who resisted change due to their own fears and the fact that many teachers are set in their own style and manner of teaching. The fear of failure was contrary to the philosophy of the SMC as dealing with misconceptions was deemed

[14] I refer to the "My pals are here" additional resource books available at each grade level which are aligned with the general class workbook. They are intended for use to support weaker students.

a valuable part of the learning process. A teacher‟s own viewpoint influenced teacher practice. The discrepancies in their interpretations of the SMC was reported as either the creative opportunity of the individual teacher who saw the curriculum in a positive light or the negative opinion of a teacher having to follow a prescriptive curriculum. Whilst Teacher A and Teacher C reported on a teacher having negative experiences working with the SMC, this viewpoint was not from their own personal regard. Teacher A admitted how her attitude has changed and seeing mathematics as being of worth enabled her to encourage and praise her students a lot. This positive disposition also reduced their fears of students when getting an answer wrong. She shared a change in attitude from students in her class and one exclaimed "Teacher A you love mathematics and I also love mathematics because I can do it".

Beliefs about teaching mathematics may contradict educational policy or democratic ideas such as equity and gender issues. As teachers in the FG agreed with the sentiments of Kilpatrick et al (2001) and concurred that "All teachers must learn to think mathematically and think mathematically to learn", then the assumption is that teachers will employ strategies to enable all learners to learn in this way.

The teachers concurred that whilst conceptual understanding and procedural fluency are extremely important in the teaching of young children, the values in mathematics are the affective qualities that will be remembered longer in the student‟s memory. How they felt about maths will determine their disposition towards the subject throughout their lives and hopefully the term I can't do maths will not be heard in a class where SMC is implemented.

Tension between one‟s own belief on the nature of teaching and learning mathematics versus one‟s actual practice was left inconclusive in this study. What was feasible to ascertain, was the view of the nature of mathematics and the specific qualities of the SMC worth promoting.

4.3.4 Focus group presentations

The teachers‟ final presentations took place on the 22nd March 2011. My supervisor from Rhodes University travelled to East London to be part of this summative workshop. Each member of the focus group presented her story about her experiences and the teaching of SMC in her own classroom. These presentations were unique and extremely personal accounts of the individual teacher‟s experience. Some presentations were in the form of a power point presentation with or without handouts. Other

teachers chose to use visual aids to illustrate what had been of particular significance to them in their teaching experience. Along with the handouts presented to members of the focus group, an enormous amount of data was able to be discussed and generated from these presentations. I noted all their stories in my field notes.

Teacher A shared how her negative experiences and fears of mathematics had slowly changed as she gained in confidence using the SMC curriculum where she felt comfortable and understood the importance of children making sense of number. Her sceptical view point of implementing a foreign curriculum also related to how they used mathematics vocabulary. She shared her own personal change in attitude and how as a teacher, she was seeing mathematics of greater worth. Working with the SMC helped her realise that she and her students can achieve success in mathematics.

She felt the level of speaking and understanding the language of mathematics has been raised in her class and the focus was on what children could be able to understand. This child-centred approach was spelt out clearly for her as she took a strong lead from the teachers‟ detailed guideline manual. The model method was a turning point for her and as a Grade 2 teacher, she regards her role as being one as a teacher always learning new things and travelling a journey with the class.

The final presentation from Teacher B was presenting a framework encompassing all of her experiences and what SMC entails from the perspective of a Pre-school teacher. Teacher B had continually consulted the curriculum across the grades when teaching Singapore Mathematics. This was enlightening for her as she had a clearer picture of the flow of syllabus. She described how both she and her students were enjoying mathematics. She spoke about the crucial role of creative play and how to use numbers that are appropriate to a five year old. In the Grade R curriculum, she had managed to use experiential learning with a variety of apparatus to create a curiosity into number patterns and making sense of number.

Teacher C compared her experiences as a maths teacher before implementing the SMC to when she was working in a government school. She described her view of mathematics only from a teacher‟s viewpoint. She had taken her lead from more experienced teachers who played a mentor‟s role. As a teacher herself, she questioned the number ranges which she felt got too big, too quickly. She felt bound by the national curriculum. Her frustration with different pedagogy resulted in her being

compliant and teaching as she was instructed. Previously she was focusing on teaching concepts and showing how to do calculations. Most of the time was spent on written work and the teaching of maths was expecting students to work predominantly in the abstract. Whilst enjoying the top group successes, she admitted to being frustrated with the weaker children and she never worried about how pupils felt about maths as they just had to do it. The differentiation of work cards was more about doing your own work and not coping, as the lessons were quieter with little discussion or peer interaction about maths and she gave instructions from a chair informing and telling rather than questioning for understanding.

Her approach to maths has changed radically using the SMC. She describes it as I made a complete 180 degree turn about, restoring her original love of maths as a student. Now she is excited with the challenge of catering for all students and in particular, the "now I can see" exclamations of weak children. She shared feeling comfortable with the number ranges and whilst following the curriculum, is able to use her own initiative.

What changed? She answered that her role as teacher has been the biggest change. She enjoys watching the children learn and experience hands on the love of learning about numbers as most of her lessons are spent using manipulatives on the mat as the children discover and learn. Resources in a private school play an important role and the rationale of working in a 3 step approach, from the concrete to the semi-concrete and then into the abstract is what resonates with her view of maths using the SMC and the allows children to share and discuss what they are doing. The fact that the whole class is working on the same activity allows for greater discussion and sharing of ideas. She has been able to withdraw from a teaching role into facilitating tasks because the students are so actively engaging in their own learning and gaining knowledge and insight within a social construct.

The in-service training of the SMC had not benefited her, but she preferred trying to work it out herself with colleagues. The teacher guides provide all the basic information she requires to teach the SMC.

Teacher D presented her experiences with a strong emphasis on the knowledge needed for teaching and the process of teaching mathematics where understanding is of such importance. She stated that the lessons must always allow children to work in the concrete and let them discover solutions for themselves. The logical flow from hands on activities to show the step by step flow through semi-concrete pictorial was viewed in her power point. Examples of children working in groups and using the workbooks were also shown. She feels that they clearly supported the absence of tricks and clues in

learning. Understanding was more important than procedures, in her opinion, and yet the correct ways of solving problems and coming up with their own solutions was important. She demonstrated examples of students working and playing with numbers in the photos that were included.

Teacher E shared her experiences explaining that her own school learning had been grounded in a very positivist approach to teaching where, without much apparatus and little understanding, she had had rules and procedures drilled in order for her to remember what she had to do within a mathematics lesson. This had not been a positive experience and maths was seen as a subject to learn the rules and then apply them when working out the answers. The role of language has had a huge impact on her teaching whilst using the SMC as through discussion, she has seen how meaningful the learning can be for the students. Her role is to encourage students to think for themselves and come to understand what they are doing with numbers to make sense of the relationship between numbers. The new approach and trying out the model method using strips of paper to estimate the bigger numbers has been a very rewarding teaching experience for her. Her initial scepticism about the students‟ ability to use the model method has been defused. The students‟ understanding of the model method has been rewarded by their working out of problems such that it makes sense, is accurate and they can explain their own rationale in how they are solving problems.

Teacher F has always had a love of mathematics and her enquiring mind has led her to deviate from the actual Singapore approach from a creative point of view. Her solid pedagogy has always made her feel confident to teach mathematics and she sees the logic of working with numbers as a life necessity for all students in her class. The task she sets students has a fun, hands on approach and this is what she enjoys about SMC, supporting her belief that mathematics is fun and games play a big role in the learning and making sense of numbers.

Within the teaching of mathematics, she referred to the relationship between the teacher, her individual students in the class and the mathematics content. The knowledge of each student and their needs is an important part of the teaching of mathematics and her focus within the SMC is to allow each student the opportunity to learn using their own methods and ways of discovering where the teacher guides their thinking and sets appropriate tasks as per the individual child.

From the individual student learning mathematics in a logical way, she described the importance of the spiral curriculum and the notion of mathematics as a fun process which flows from one concept to

another. She feels that the Singapore‟s bar modelling technique is a technique that allows students to understand the mathematics of the problem and obtain the correct answer, rather than using a trial and error approach.

4.4 PHASE 3: SYNTHESIS OF SIX TEACHER EXPERIENCES

In this phase of data analysis, the synthesis of the above practices will be structured according to Kilpatrick‟s et al. (2001) five strand of teaching for mathematical proficiency which I stated was my intention in the literature review. In chapter 2, I stated that I intended to use the five strands of teaching for mathematical proficiency as a conceptual framework to analyse elements of the SMC teaching practice. This will be my lens to discuss, reflect and report on the data findings. The lesson observation schedule (Appendix A) on teaching for mathematical proficiency provided a useful tool for the teachers to consult when observing lessons. I have incorporated this schedule into my discussion, using the specific five strands of teaching for mathematical proficiency as headings below.

4.4.1 Conceptual Understanding

Having considered what conceptual understanding for effective teaching meant to the different teachers, I found that whilst they all considered understanding in different aspects of their teaching to be important, there was not agreement on the all encompassing understanding of what conceptual understanding actually entails.

All the teachers agreed that the SMC fore grounded conceptual understanding. This was strongly reflected in the SMC materials and assisted the teachers to teach conceptually. Teachers had no difficulty recalling mathematical concepts they had not understood in their student days. The teachers mentioned that the role of effective questioning was central to conceptual teaching and understanding.. They all identified strongly with the SMC principle to recognise what students already knew and then using this prior knowledge in their teaching. They felt it was important to afford students opportunities to demonstrate and explain their own ideas. The recognition of prior knowledge that students brought into the class was identified as being of important in their teaching practices. Of particular interest to me as the researcher, was the teachers‟ reporting of how the weaker students had benefited conceptually from the SMC. Teachers acknowledged that it sometimes was time consuming allowing students to make sense of mathematics in their own way. When trying to understand concepts, weaker students generally learn at a different pace. The commitment of these teachers in addressing this

consideration was deemed very positive. Their goal was to ensure more students could come to understand mathematics. The time factor was a challenge for teaching yet crucial for students in learning with understanding. The teachers had shared the SMC placed more importance on understanding than arriving at the correct answer. The evidence showed that the depth of understanding for students replaced the memorisation of rules.

The actual understanding of the mathematics specifics to be taught varied amongst the members of the focus group. The need to know more than your students was not deemed crucial by all. At this level of teaching, the more profound an understanding of fundamental mathematics the teacher displayed, the more teachers could appear to understand why having a greater understanding of the mathematics would actually enhance their ability to teach for success. Where a teacher had made a mathematical error, it suggested to me that their own grasp of the curriculum material was not as deep as it should be. This is where I concur with research in the SMC that argues for more continuous professional development of teachers to be trained in the content of mathematics. The teachers commented favourably on the need for ongoing support and training. It is vital that teachers understand the rationale of any curriculum, for effective teaching to take place.

The teaching practices and pedagogy that are underpinned by conceptual understanding provide opportunities for teachers to reflect and question the understanding they have of their own instructional practice. I felt sometimes teachers don‟t fully understand why they teach the way they do, and teaching for mathematical proficiency requires the teacher to have a sound understanding of one‟s own pedagogical content knowledge (PCK). It also requires teachers to be able to make the links between the mathematics and the actual tasks that are part of the intended curriculum. The teacher‟s role is to help students develop connections between their current knowledge and new information in order to foster understanding in the students. This belief was echoed by those teachers who felt their role was to facilitate learning rather than teach what they know. I found this profoundly important in understanding for myself the envisaged role the teacher plays in teaching for conceptual understanding. In the words of Prawat, (1992) it is stated that “teachers need to be willing to rethink not only what it means to know subject matter, but also what it takes to foster understanding in students through the development of connections between knowledge and context.(Prawat, 1992, p. 361, 376).

4.4.2 Procedural Fluency

From my observations, there was abundant evidence of procedural fluency in the teaching of the participants. I also observed how the students actually went about problem solving and the ways they worked out answers in different mathematical calculations. The SMC three step approach to finding solutions afforded every student the opportunity to work with concrete apparatus or manipulative as the first procedure to follow. Generally all tasks commenced with the physical handling of objects by students and the development of procedural fluency and the skills used could be supported by what the teachers discussed. When the teachers were teaching for procedural fluency, they reported and actually taught according to very logical steps and their instructional procedures showed a flow of activities and events. There was a progression of tasks according to the SMC and the teachers were able to complete these teaching tasks or strategies. The management of both the classroom and the actual mathematics activities showed that the implementation of the SMC provided for the acquisition of these skills. The way the teachers could adapt and be flexible to cater for the situations and needs that arose during the mathematics lessons, indicated that they had grasped the way in which procedural fluency can be embraced in order to promote successful learning and teaching.

Where the teaching for procedural fluency was most evident was through the use of hands on activities and the promotion of discovery of mathematical concepts. Here the teachers spoke about the way the students were carrying out procedures and doing mathematics in more flexible and accurate ways. This demonstrated the teachers‟ understanding of procedural fluency as they communicated with students, ensuring there was a flow to their skills carried out. This linked the conceptual understanding to the procedural skills being carried out, showing the interdependence of understanding and what we do in mathematics. The teaching skills employed by the teachers alluded to the assistance they had received from the SMC teachers‟ manual. The focus group had afforded them practical hints on how to improve their teaching skills as they shared their SMC experiences.

Kilpatrick et al., (2001) claim that Procedural Fluency for effective teaching means that teachers are able to competently perform teaching tasks which teach the concepts. When working with students the teachers should have a range of different approaches for teaching mathematical concepts to draw upon. Teacher F placed particular importance on the relationship between the teacher, her class individual students and the maths content in the mathematics lesson. Kilpatrick et al., (2001, p. 314) view the teaching and learning of mathematics as the product of interactions among the teacher, the students

and the mathematics in an instructional triangle. Of importance is how the teacher carries out her instruction through the interaction among the teacher, her students and mathematics in different contexts.

4.4.3 Strategic Competence

In my observations there was much evidence of the different ways and adaptations of teachers using the SMC in their teaching. Whether they commented on the diverse students and learning abilities in the class or the learning styles of the students, it became apparent that SMC allowed the teachers freedom to plan effectively and come up with activities and use questioning to cater for the different students. The referral of teachers to scaffolding and assisting students implied that this strand of teaching for mathematical proficiency was present. The use of group work and collaborative learning implied the teachers were coming up with opportunities for all to learn effectively.

As problem solving is central to the SMC, the process skills involved in being able to come up with one‟s own solution strategy and solve it are important. But of equal importance is the understanding of what we do and how we do it. Strategies to acquire and apply knowledge to solve problems in teaching and learning are explicit in the SMC. The teaching of heuristics or thinking skills are included in the SMC. Teaching the model method to represent a problem visually or taking a whole number and making two parts from the whole are two such strategies taught. I was fascinated to discover that whilst teachers responded that the SMC was not prescribing a specific methodology to take priority, no teacher alluded to the notion that the SMC model method in general was overly prescriptive. Was this because the teachers like the model method, or was it because they don‟t appreciate exactly how prescriptive the SMC is? Teacher F was the only teacher who grappled with the preference of a specific methodology taking precedence. I am aware that she is continually looking for ways to ensure that all students can come up with solutions that makes sense to them. She acknowledged the need for efficacy in her teaching routines. She is instructing students to work accurately and efficiently as they are older and working more and more with certain procedures.

Although the role of the teacher as a facilitator is never explicitly stated in the SMC, the nature of the SMC mathematical problems are such that the teacher distances herself from the task and lets the students discover their own solution strategies.

4.4.4 Adaptive Reasoning

As the teachers thought logically about their own experiences using the SMC, we became more aware of the need to apply adaptive reasoning. I looked for the incidents where the teachers had reflected or reportedly changed in their own practice. Could they come up with a sound argument as to why they performed a particular instructional routine? Have I applied logic in carrying out this research study and can I reflect and explain why I followed the methodology as I did? The focus group provided an opportunity for all teachers to share and explain their practice in a non-judgmental way without fear of any criticism. The teachers were not asked to provide evidence to justify claims they had made. For me personally, it is when one"s adaptive reasoning is questioned that I have come to understand the true worth of reflective questioning and thinking. My readings of the scholarly literature in mathematics education, along with the experiences of the six teachers in the focus group, have yielded further considerations for me to reflect on. One is continually questioning, revising and undergoing change if you have a dynamic view of mathematics. I am of the opinion that every one of the teachers in the focus group has come to appreciate the capacity for logical thought, but cannot attribute this to the implementation of the SMC. The need for teachers to critically analyse their teaching strategies in terms of teaching for mathematical proficiency is emphasised by Kilpatrick et al. (2001). When the teachers unpacked and discussed aspects of a task, they commented on how the teacher being observed, had shown initiative in linking ideas to help the students explore alternate ways of finding solutions. The intrinsic instinct of the teacher to come up with logical suggestions was regarded as evidence of adaptive reasoning in her teaching.

4.4.5 Productive Disposition

The teachers have been so enthusiastic about the SMC and have repeatedly given positive input into this research. They have enjoyed the learning experience. Their determination and commitment to succeed in the implementation of the SMC resulted in many positive changes in the teachers" attitudes towards mathematics and teaching. Taking note of how teachers" changed over the research period was fascinating for me. Teacher C in summing up her experiences shared **I just liked the whole changing of the attitude of the children.** She added that she is a more confident teacher and her highlight in teaching SMC was seeing the weaker kids when they get that **aha moment**. Productive disposition for effective teaching requires diligence in teaching. The teacher needs to view the teaching of mathematics as being of worth. The attitudes of the teachers in this study confirmed the overall enjoyment and appreciation of mathematics when using the SMC. The attitudes and confidence of the

students were continually reported as was the enjoyment and interest of students in the SMC resources. The teachers stated that they had particularly enjoyed the SMC because of the way students had engaged independently and in groups with SMC activities.

For the effective teaching of the SMC, the five strands need to weave together as seen by Kilpatrick et al., (2001). Teaching is indeed a complex practice and the five components discussed above were all observed in varying degrees according to the observation schedule I used.

4.5 INTERNATIONAL REPORTS AND CONSIDERATIONS

As I noted the experiences of the teachers in my focus group, I am aware that the reports from the two studies completed in 2010 in the United States support my findings in many ways. The anecdotes from the teachers are very similar to the experiences of the South African teachers, particularly when discussing the role of language. Success could be attributed to the teachers‟ communication skills and explanations of unfamiliar words and terminology.

The students who are speaking a home language other than the language of learning and teaching have sometimes needed additional support and explanations to assist their understanding. Taking cognisance of the cultural and social differences between a South-East Asian country and one in either Africa or the United States could raise a few concerns when implementing a foreign curriculum. As the role of language plays such an integral part in mathematics education, the use of foreign, unfamiliar words can be inhibiting to a student in an African context. The students in the United States represented a large percentage of a growing Hispanic population where they are English Language Learners (ELL) and their mother tongue is not English. The SMC has been described by teachers as a curriculum which is vocabulary rich. This could prove to be difficult or confusing for the students whose mother tongue is a language other than English. Introducing familiar vocabulary in place of foreign names is advocated. An apple or a banana in everyday life in Africa makes more sense than eating a fruit called a durian. Similarly, the currency used in Singapore is the Singapore dollar and not the South African rand. Whilst it is a decimal system with a hundred cents equating to a dollar, yet again further explanations are necessary for a student to be able to transfer or convert money when using a foreign currency. Unless carefully and purposely included in a mathematics lesson, this has the potential to be problematic for some students. Here the adaptive reasoning of the teacher became evident as she questioned the students as to what they had thought and done to make sense of a foreign currency.

Conversation about mathematics terminology and constructing stories are an integral part of the SMC learning. It is thus important that the SMC materials are contextualised and customised in a language that is accessible to the students. The customisation of the books for the United States, for example has been welcomed by the teachers there.

4.6 CONCLUSION

In this chapter I dealt with the analysis and interpretations of the study findings. The study intended to analyse the experiences of teachers teaching the SMC and aimed to determine whether teaching for mathematical proficiency was evident. Whilst the collection of data occurred in three stages, it was a recursive process and the considerations of the individual thoughts were captured continuously. The interaction between members of the focus group kindled a growing aspiration to best practice. It was indeed a privilege for me to work alongside teachers who allowed me into their world. I gained new insights into a community of learners, where I learnt to reflect on their considerations and gained some valuable lessons into how they were enacting the SMC.

The five strands of teaching for mathematical proficiency enabled me to weave together the various components of the teachers‟ implementation of the SMC. Teaching is a complex activity and yet the common concerns that the teachers shared could be broken down, simplified and solved. The focus group discussions could be broken down into themes. The individual teachers shared their knowledge and the group drew on the knowledge discussed.

In summary, from the data I established that:

- The teachers viewed their role as central to the successful implementation of the SMC;
- The ratings of the SMC according to each teacher were positive, constructive and based on personal experiences;
- The themes identified through focus group discussions indicated conceptual understanding and procedural skills as equally important in the teaching for proficiency;
- The teachers reflected a positive productive disposition towards mathematics and its pedagogy;
- The teachers shared that the research study had been an opportunity for their own ongoing professional development.

The personal experiences of the teachers and how they went about their daily practice reflected an overall positive view of the worth of teaching the SMC. In terms of managing the concerns and challenges that arose in implementing the SMC, the teachers invariably came up with creative solutions and innovative strategies to address these. The study also revealed the value and importance of mathematics in general, the need for quality teaching, and a sound curriculum at the Foundation Phase of schooling in South Africa.

CHAPTER 5
CONCLUSION

> Education is about opening doors for our children; And giving them hope and opportunities. It is more than filling a vessel with knowledge; It is to light a fire in our young people.
>
> Lee Hsien Loong, Prime Minister of Singapore[15]

5.1 INTRODUCTION

This research has allowed me to investigate how teaching practice can promote the development of mathematical proficiency. I wanted to find out if the introduction of the SMC informed teacher practice. I found that teachers using the SMC reported going beyond applying well-rehearsed procedures when solving problems. They stated that they had learnt how to come up with their own strategies to teach with understanding and logical reasoning. Investigating the practice of teachers using the SMC and listening to their stories and experiences has been most enlightening, uplifting and rewarding. A most compelling lesson reiterated throughout this process is that the role of each teacher (as mentioned in Chapter 2) is pivotal in the successful delivery of any curriculum.

My primary objective was to consider the individual experiences of each of the six participating teachers in my focus group when implementing the SMC. I wanted to ascertain whether an alternate curriculum could enhance the teaching opportunities and create a deeper understanding of mathematics education for these South African teachers. What I had not envisaged was the potential worth of a focus group collaborating to share their experiences. Whilst the teachers within the focus group respected the individual‟s viewpoint, they reached consensus on many principles of good teaching practice. As they became more open to sharing, greater opportunities for co-operative learning in their instructional practices arose. They reported that the meaningful learning that occurred in the focus group had a positive impact on their classroom practice. Their newly-discovered strategies and sentiments were manifest in their practice. The teachers‟ central role was again shown to be key to the successful teaching and learning of mathematics.

[15] The Honorable Prime Minister opened the 9th World Convention of the International Confederation of Principals. Singapore 6 July 2009.

5.2 SUMMARY AND DISCUSSION OF MAIN FINDINGS

I believe that this research has provided evidence to support the idea that the implementation of the SMC has the potential to enhance successful teaching and learning in mathematics. I believe, too, that the study can serve as a useful point of reference for any person trying to improve the teaching and learning of mathematics in the Foundation Phase in South Africa.

In general, the SMC was well received, with the participating teachers isolating the following features:

5.2.1 Positive features were found to be:

- The teachers and students were enjoying the discovery of mathematics using a variety of manipulatives as required when using the SMC;
- The use of the model method, a specific feature of the SMC, to solve problems helped students visualise mathematical problems;
- The teachers‟ understanding of teaching for mathematical proficiency was enhanced;
- The spiral curriculum informed the teaching practice by allowing the building onto concepts already mastered, creating a logical flow of ideas and carefully progression;
- Whilst the SMC provides a more structured approach to the teaching and learning of mathematics, it provides constant opportunities for creativity and logical thinking, and
- The change in attitude of both students and teachers has resulted in greater confidence when they work with non-routine, open-ended problem-solving activities.

5.2.2 From a critical perspective the participants found the following problematic when implementing the SMC:

- All the teachers‟ felt there was a lack of sufficient drill and practice once the concept was understood. More practice and exercises were called for;
- The whole class teaching approach with every student having a textbook and workbook pertaining to the lesson required a change to classroom management; and
- To obtain a deeper understanding of number concepts was time consuming, and re-teaching the weaker students called for additional time and adjustments to the timetable.

The teachers confirmed that the majority of their students were actively engaged in learning activities and showed a keener interest in learning about mathematics. The students were enjoying mathematics lessons and the anxiety level of some students had decreased as they were free to use concrete

apparatus when working on solving mathematical word problems. When students responded to the fun activities and played the various games as set out in the SMC textbooks, their enjoyment of working with number brought a greater interest in mathematics into their world.

From the teachers responses it was evident that the students were able to make greater sense of number. This included the use of the model method, a specific feature of the SMC, to problem solve. Teachers described how students were able to employ their own constructed solution strategies in problem solving. An interesting outcome of the study is that the teachers reported that students appeared to be more proficient in solving word problems and having conceptual understanding when doing so. This is in the context of the research on word problems that has shown that teachers find them difficult to teach and learners find them difficult to understand. As problem solving is central to the SMC, the use of problem solving and trying to overcome challenges was a strategy used by teachers when interacting with other members of the Focus Group. Teachers confessed to their innate tendency to speak out and provide answers before allowing students sufficient time to engage with the challenging tasks independently.

The findings of this study noted the teachers‟ role in fostering understanding of mathematical concepts and discovering how to make effective use of procedural skills when teaching. It highlighted certain issues and challenges for mathematics teachers trying to improve their practice. Furthermore, this study has significant pedagogical implications for teaching in the Foundation Phase of mathematics.

If the teacher regarded the SMC as a potential vehicle for change for the better, the attitude to the change was positive. The teachers‟ attitude to mathematics was also influenced by the performance of the students.

If a teacher has a specific view or belief in mathematics education, she appeared to carry out instruction in a way consistent with those beliefs. This, however, is contrary to Brodie (2001) who argues that there can be inconsistencies.

The role of the mathematics teacher is pivotal in curriculum delivery and managing change. Observing the practices of teachers who have taught using the problem-centred approach has resulted in their becoming more open to change and more flexible in their own teaching style. The experiences of all the teachers confirmed that they have gained in their own conceptual understanding of teaching for mathematical proficiency.

The findings of this research appear to endorse the proposition that the five strands of conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition are what is entailed in the successful learning and teaching of mathematics. “Problem solving should be the site in which all of the strands of mathematics proficiency converge” (Kilpatrick et al., 2001, p. 421: whether it is through students working on a problem in a classroom or teachers sharing their experiences in a focus group and trying to come up with feasible solutions, our ultimate goal in mathematics education should be to inculcate mathematics proficiency in our students.

Each teacher was key to effecting curriculum change when implementing the Singapore Mathematics Curriculum. The value of working to understand a curriculum is that it provides teachers with an opportunity to reflect on their own teaching and pedagogy. However, no curriculum can be successfully implemented if the teacher does not have a sound knowledge base on which to build her teaching practice. Curriculum delivery is strongly influenced by the role that the teachers play in socially constructing their own meaning of the curriculum. I acknowledge that the teachers in this study did make mathematical errors, suggesting that their own grasp of certain concepts and material was not as deep as it could be. It was discovered that the following factors are crucial to the successful implementation of the curriculum:

- That the teacher relates to the mathematics content and the students in a positive way;
- That time factors are addressed as teachers require time to prepare for curriculum change and time to be trained in the curriculum itself;
- The implementation itself takes time;
- Learning from Singapore where students are among the top international performers in mathematics today is beneficial, provided the teacher is able to adapt the curriculum to cater for the needs and different learning styles of the students in the South African classroom;
- Ongoing professional support and training for teachers will afford them opportunities to share and learn about best practice from colleagues, and
- In a country where the perceptions of teaching practice and the role of the teacher are at an all time low, it is my belief that we need to invest in high quality in-service teacher programmes to ensure that teachers are proficient, equipped and adequately rewarded for the positions they fulfil in the noblest of all professions.

5.3 REFLECTION AND SIGNIFICANCE OF THE STUDY

5.3.1 Significance of this study

Any significant response to a challenge starts with one small step forward and, in my case, some niggling questions. Can the SMC work in South Africa? I believe the SMC has the potential to be successful, but we need to consider the factors that contribute to the successful implementation of a curriculum. Although my findings are to be viewed only in the context of the two participating schools, the study has shown that the introduction of the SMC has the potential to make a difference in the learning of mathematics at the foundational level of schooling. I believe that there is sufficient evidence to encourage other schools to consider its implementation.

There were limitations to the project. I was investigating the experiences of a select group of teachers and carrying out this research for the duration of only one year. The entire project could have produced outcomes not expected or envisaged by myself. I had to be honest, brave and open to change. I soon realised, however, that there are indeed some teachers who are inquisitive, open to change and willing to go out on a limb to try new approaches to assist their students. Despite a possible lack of curriculum, mathematical or pedagogical content knowledge, they were willing to try to make a difference. By carrying out this research I realised that there is something we at the early school entry level can do to change the state of mathematics learning in our own area.

The findings of the reports from the United States, which I obtained eighteen months after the commencement of this research, have added credibility to my findings. Whilst I may well be submitting the first thesis in our country pertaining to the SMC, I am encouraged by the fact that mathematicians and academic researchers in other parts of the world have also chosen to research the SMC and its implementation in their countries. The results from the United States indicate significant improvement in students‟ levels of mathematical proficiency (Educational Research Institute of America, ERIA, 2010a). The students in the United States included a large percentage of a growing Hispanic population who are English Language Learners (ELL). I therefore encourage other schools in South Africa, including those with students for whom English is an additional language, to adapt the SMC to suit their needs and implement a curriculum that has the potential to improve mathematical proficiency.

The current crisis in mathematics is not an insurmountable problem. Research can and needs to inform practice, and practice can inform research to make a difference in South Africa.

5.3.2 Personal reflections

As I embarked on this research study, I soon realised that my role was more that of a student, anxious to come to grips with the reality of best teaching practice. I have always espoused the idea of lifelong learning, but for the first time came to realise that no learning is of benefit to a teacher if it doesn"t challenge her to improve and become a better practitioner. This study was covering relatively new ground in South Africa. When one is entrusted with the responsibility of educating the youth of our society, one risks becoming an uncritical disciple of a theory that suits one"s current needs. Was I embracing the SMC blindly and convincing myself, without tangible evidence that it could be of benefit in our education system? My professor urged me to pursue this study as a critical scholar and be open to my findings. Society"s expectations of leadership include the demonstration of scholarly leadership through evidence of effectiveness in teaching and learning. Having accepted the responsibility of supporting a curriculum to enhance learning and mathematics education, I had to continually guard against my intuitive thoughts and remain true to the ethical considerations of research. We all, especially teachers, have a responsibility to be part of the solution to solving the crisis in which we as a nation find our mathematics education in South Africa. Scholarly leadership includes the dissemination of knowledge through professional practice to apply this knowledge for the enrichment of a community. We can no longer refer to the teaching of mathematics without seriously engaging in all five strands of mathematics. We need to rethink our own understanding of meaningful engagement with numbers and ensure that we are modelling proficiency in teaching mathematics in the classroom. In management tasks as in mathematics lessons, are we structuring our activities and the environment in which the students learn to readily support meaningful learning? Conceptual knowledge and a sound understanding of numbers need to become our primary goal for every student in mathematics education. Do our students know what, when and how to proceed with problem-solving and seek solutions with perseverance and enthusiasm? Is procedural knowledge coupled with sound reasoning ability making useful meaning of the world of numbers in which they live? I believe the answer to all of these questions should be yes, and my study has shown that the implementation of the SMC has gone a small way toward enabling this affirmative response.

5.4 DILEMMAS AND ARGUMENTS

Introducing a foreign curriculum is contentious. My research was mindful of this and I have therefore presented a story of the SMC based on rigorously collected data and in-depth discussions. I considered a number of factors from the findings that showed that the successes and positive aspects of the SMC outweighed a few challenges and areas that needed to be adapted to our context.

The question of anonymity had the potential to present as a dilemma. After I had gained consent from all the teachers and both schools to proceed with the research, ownership of the research project took on a different slant. Having agreed to anonymity, some members of the focus group felt they would prefer their names to be recorded as a personal acknowledgement of the validity of the findings of this research study. As the project was carried out by extremely committed and enthusiastic teachers, they felt proud of the personal and collaborative research data. They felt that they wanted to show-case their own practice and their schools. But my view was that other, more appropriate opportunities would present themselves for this showcasing to take place in the future.

5.5 LIMITATIONS

With reference to the limitations discussed previously in Chapter 3, all the teachers involved in this small-scale case study were volunteers from well resourced, well governed schools. The study context is therefore not representative of the majority of schools across South Africa. The study did not include teachers from rural schools, nor were teachers or students drawn from a wide range of different cultural groups.

Constraints of time have to comprise one of the most limiting factors in this research. The time I could afford to spend on studying whilst heading up a school could not do justice to the richness of an exercise of this nature for me. I hope it has not limited the value of the exercise for the teachers in the focus group. The participants and I would have liked to have had more time to reflect on the aims and processes of this study.

Another limitation is the reality that dedicated teachers never find enough time in the day to meet all the demands of their profession. Teacher training and the acquiring of knowledge, be it of the subject, the students or the pedagogy, is an ongoing process.

5.6 GAPS LEFT IN THE STUDY

One of the possible stumbling blocks to the implementation of the SMC in South Africa is its misalignment with the South African curriculum. Although the participating teachers regarded the SMC as an enhancement of our current curriculum, they at times found it difficult to implement it concurrently with the South African curriculum. Whilst there is a significant overlap of concepts, the SMC covers fewer concepts at a much deeper level of understanding. This is an area that was not addressed in this study.

At no stage was any test administered to assess the mathematical knowledge or performance of each individual teacher. The correlation between the teacher‟s personal mathematics knowledge and her knowledge of how to teach for mathematical proficiency were drawn only from teachers‟ conversations and articulated experiences. No instrument was used to corroborate what the teacher claimed by checking on her actual mathematical knowledge, although there was no evidence to suggest that any such discrepancy existed.

5.7 RECOMMENDATIONS FOR FURTHER RESEARCH

This study could potentially pave the way for further research in:

- Larger-scale research on implementing an alternative curriculum;
- Further curriculum development and adapting the SMC to the needs of the South African teacher and student. Translations of the resource books into an African language would be an example of this;
- The roles of a teacher in the improvement of teacher practice;
- The value of teachers sharing their best practice and supporting the value of ongoing professional development;
- In-service training and ongoing professional development needs, and
- A pilot group of teachers volunteering to carry out research in an under-resourced school.

5.8 CONCLUDING THOUGHTS

I valued the role and contribution of each teacher in my study and share these closing thoughts:

You may take the best of the best curriculum and incorporate it into your teaching.
It is the person in front of the class, asking sound open-ended questions and getting students actively involved in discussions, showing empathy to the needs of different students, whilst providing concrete and pictorial approaches for conceptual understanding, who matters.

It is the teacher who questions and strives to help every student to develop higher order thinking skills that will make the difference in mathematics education. Teachers using the best curriculum can do a poor job, but if they are supported by a world class curriculum they will be more likely to succeed in teaching for mathematical proficiency.

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APPENDIX A

Kilpatrick Conceptual framework for observing a lesson.

AREA OF FOCUS	1 CONCEPTUAL UNDERSTANDING	2 PROCEDURAL FLUENCY	3 STRATEGIC COMPETENCE	4 ADAPTIVE REASONING	5 PRODUCTIVE DISPOSITION
1 PRESENTATION OF A LESSON BY THE TEACHER:					
Clear **introduction of concepts** at the start of each section of the lesson.	Evidence of the teacher's mathematical knowledge & understanding of concepts	Can flow from basic to deeper or from one idea(more) into addition	adaptations to cater for different learners in design of lesson – diversity in design	Evidence of recognition/referral to prior knowledge can think back/reflect	Attitude & evidence in a prepared, comfortable topic Teacher happy to use and discuss different approaches
The **role of questioning** Questioning – Prior knowledge (use of language) - asking - own understanding - Consolidation/ - revision / recall Questions related to adaptive reasoning – why it worked/didn't work/ what could we have done?	Recognizing prior knowledge To obtain clarity To enhance understanding	Questioning to promote the flow of lesson – sequencing of tasks Facilitate steps to recall what student has done	Children explaining and answering in their own way Ascertain different ways to come up with explanations	Justifying is a key element of adaptive reasoning and evidence of allowing concepts and procedures to connect together in sensible and meaningful ways.Questioning logic Questions related to adaptive reasoning – why it worked/didn't work/ what could we have done?	The teacher's attitude Noting the students' attitude to questioning and how they respond Encourage, see worth of exercise, exciting versus boring attitude to questioning
Problem solving approach	Understanding central to problem solving	Using problem solving to facilitate procedures	Problem solving to formulate and come up with different teaching strategies	The use of problem solving in teaching to justify one's instruction and methodology	Teachers to persevere in finding solutions to problems encountered
2 THE IMPLEMENTATION OF LESSON: WHAT CHILDREN DO					
Engagement of children the flow within the lesson use of resources methodology – what kind of strategies are used specific to 5	Understand idea – knows terminology, operations & relati0nships. Can use different representations	Able to do procedures & follow steps – not rule driven but can adapt procedures to their understanding	Understanding concepts & PF allows for knowing when to use in PS. Can formulate, represent & come up with solutions	Develops structured logical thought processes. Can reflect, explain & justify method	Sees mathematics as useful, will persevere to find solution & make sense of number
Children's use of **manipulatives** and resources in tasks	Doing for themselves helps them understand	The physical ability to do things step by step in a flow	Seeing differences Using different strategies	Hands on experience to justify/explain	Confidence to share experiences to make sense/fun in games & doing
Teacher – Pupil - mathematics interaction **Communication** and the role of language and managing the class discussions	Conversations catering for learners' needs to make sense - explanation of different children's answers (and learning styles)- generating new ideas the level of learner engagement				Pupil – teacher interaction (HR skills) The teacher's attitude The student's attitude
Time & Allocation of time per topic – consideration to adequate time?AR	Time to understand	Time to carry out procedures	Time to think and recall	Time to think in another way / evaluate	Constraints –Pressure
Individual versus Group work	Use of a textbook, resources	Analysis of responses	Opportunities for **ALL**	Opportunities for **ALL** to	Group dynamics for creating

	and support material to aid understanding by an individual or in group work	made by students – logical flow of ideas	learners to ask either of each other or questions from teacher and group discuss to formulate ideas and come up with solutions	explain and group discuss to come up & justify solutions	a positive disposition Interest in the task
3 MATHEMATICS SPECIFIC: (THE ACTUAL TASKS) content appropriate to lesson & questioning within lessons	Understanding the cognitive level of task Conversing Explaining Thinking Demonstrating	Flow of lesson – sequencing of tasks Levels, examples allowing progression	Finding ways to solve task Own questioning Using prior inowledge	Thinking about actual task Justifying used as a key element of adaptive reasoning as concepts explained	Enjoyment Perseverance in coming up with an answer
Maths specific topic – **content appropriate** to lesson & questioning within lessons	Understanding the cognitive level of task	Levels, examples allowing progression	Questioning, using prior knowledge To find ways	Questioning to think about tasks	Challenging vs boring
4 FINISHING OFF A TESK Feedback to learners	Collates all ideas for greater understanding	Incorporates step by step procedures in consolidation	Linking to other situations and presents homework or further suggestions	How teacher deals with explanations in conclusion	Positive feedback Seeing the worth of the lesson
4 CLASSROOM CULTURE:					
Environment – classroom conducive to learning and learner space – does it support learning?	Conversations catering for learners' needs to make sense - explanation of different children's answers (and learning styles)- generating new ideas	Discipline and classroom management – the sequence of tasks in a lesson	Safe environment Dealing with misconceptions Presenting new possibilities in thinking	Opportunities in class and space supporting student's own reasoning and justifying of their work	The teacher's attitude, enjoyment, interest co-operation of students - mutual respect
5 GROUP WORK:					
Use of resources	Use of a textbook, resources and support material to aid understanding	Analysis of responses made by students – logical flow of ideas	Opportunities for **ALL** learners to ask either of each other or questions from teacher and group discuss to formulate ideas and come up with solutions	Opportunities for **ALL** to explain and group discuss to come up & justify solutions	Group dynamics for creating a positive disposition

Adapted from Kilpatrick et al., (2001)

APPENDIX B

Teacher Questionnaire: Section A

Please do not include your name – just your pseudonym

SECTION A: TEACHER INFORMATION

The number of years you have been teaching:	4 or less	5 - 10	11 - 20	More than 20
Your highest educational level:	Teacher‟s Diploma	Bachelor‟s Degree in Education	B Ed Honours in Education	Master‟s
Years of experience in math teaching per grade	Gr 1	Gr 2	Gr 3	Gr 4
Your age range:	24 or younger	25 - 35	36 - 45	46 or older
What teaching credentials do you hold for teaching math? (mark all that apply)	Grade 9 (Std 7) Mathematics	High School Matric Maths Higher Standard	Maths in Teaching diploma	Other e.g. Degree subject
What would you estimate is the current rate of your students' math anxiety:	None	Little	Some	A great deal
Do you think students these days have more math anxiety then they did in the past?	Yes	No	The same	

Comment on your own personal experience pertaining to the learning of mathematics

GENERAL COMMENT ABOUT YOURSELF

Adapted from (Furner, 2004, p. 45)

APPENDIX B

SECTION B: TEACHER'S VIEW OF THE NATURE OF MATHEMATICS

Problem solving should be a SEPARATE, DISTINCT part of the mathematics curriculum.	1	2	3	4
Students should share their problem-solving thinking and approaches WITH OTHER STUDENTS.	1	2	3	4
Mathematics can be thought of as a language that must be MEANINGFUL if students are to communicate and apply mathematics productively.	1	2	3	4
Children should be encouraged to justify their solutions, thinking, and conjectures in a SINGLE way.	1	2	3	4
The study of mathematics should include opportunities of using mathematics in OTHER CURRICULUM AREAS.	1	2	3	4
The mathematics curriculum consists of several discrete strains such as computation, geometry, and measurement which can be best taught in ISOLATION.	1	2	3	4
In K-4 mathematics, INCREASED emphasis should be given to reading and writing numbers SYMBOLICALLY.	1	2	3	4
In K-4 mathematics, skill in computation should PRECEDE word problems.	1	2	3	4
Mathematics SHOULD be thought of as a COLLECTION of concepts, skills algorithms.	1	2	3	4
A demonstration of good reasoning should be regarded EVEN MORE THAN students' ability to find correct answers.	1	2	3	4
Learning mathematics must be an ACTIVE PROCESS.	1	2	3	4
Children ENTER KINDERGARTEN with considerable mathematical experience, a partial understanding of many mathematical concepts, and some important mathematical skills.	1	2	3	4
A major goal of mathematics instruction is to help children develop the beliefs that THEY HAVE THE POWER to control their own success in mathematics.	1	2	3	4
Comment on your own view of teaching mathematics:				

Adapted from the Standards Belief Instrument by Zollman & Mason, 1992 as cited in Furner, 2004, p. 45. (Kilpatrick et al., 2001) and (Webb & Webb, 2008) were also consulted for this questionnaire.

APPENDIX B

SECTION C: RATING OF THE SMC

1	In teaching mathematics one should follow a specific "flow" of lessons as per a set manual	1	2	3	4	5
	Comment:					
2	Mathematics teaching and learning requires a concrete – pictorial – abstract approach for all topics	1	2	3	4	5
	Comment:					
3	Logic is promoted in SMC and creativity and originality play a lesser role	1	2	3	4	5
	Comment:					
4	Problem orientation should be the core of teaching mathematics	1	2	3	4	5
	Comment:					
5	The process and the correct product are both equally important	1	2	3	4	5
	Comment:					
6	While doing mathematics, understanding the topic is the most important idea	1	2	3	4	5
	Comment:					
7	Learning calculation techniques and procedures requires understanding.	1	2	3	4	5
	Comment:					
8	Formality and specific methodology take priority	1	2	3	4	5
	Comment:					
9	One should always make sure to visualize aspects of mathematics	1	2	3	4	5
	Comment:					
10	Teaching mathematics provides an excellent opportunity to promote the development of the pupil"s thinking	1	2	3	4	5
	Comment:					
11	Being able to communicate your thoughts verbally and on paper are important	1	2	3	4	5
	Comment:					
12	Practice and drill – referring to bonds and multiplication specific – within SMC	1	2	3	4	5
	Comment:					

Adapted from (Pehkönen and Törner, 2004); (Webb & Webb, 2008); based on Singapore mathematics textbooks, "My pals are here".

APPENDIX C

4 B..... Road
S.....
Eastern Cape

12 October 2010
The Head of School A
XXXXXX

Dear X and members of the Board of Governors

Re: permission to pursue my Masters in Education in Mathematics at School A Preparatory.

I am currently studying toward my Masters in Education (Mathematics Education) offered by Rhodes University Grahamstown. I completed my first year course work, which has afforded me the opportunity of writing a proposal for my thesis which is awaiting approval from Rhodes University.

As I research the role of teacher practice using the Singapore Mathematics Curriculum, I intend using teachers from both School A Preparatory and School B Preparatory. I am currently working with a focus group of volunteer teachers from both School A Prep (2 teachers) and School B (4 teachers). All meetings have taken place outside of school hours and the focus group meet at my home. This will afford the teachers opportunity to share their expertise and become critical reflexive practitioners as they contribute to the data of this research. The case study is a qualitative research on teacher practice specific to the use of the Singapore Mathematics Curriculum within the South African context.

I ask permission from you

1. To video extracts of mathematics lessons from teachers within the focus group. This will afford the teachers opportunity to share their expertise and become critical reflective practitioners as they contribute to the data within this research.
2. In addition, written permission will be requested from every parent of each class to share these tapes within a focus group.
3. As I endeavour to gain a broad and critical perspective on Mathematics Education in the context of my own personal space within East London schools and the Eastern Cape, I also need permission to divulge the name of the school when sharing current developments and comparing with global trends outside of this research.
4. Confidentiality is guaranteed for teachers and no names of students are divulged. The teachers make use of pseudonyms in my thesis analysis.

Once permission ids given, I will arrange with the above named 2 teachers regarding times during the next 2 school terms. All relevant information will be shared with participants and I will gladly offer School A a PDF of my final thesis at the end of 2011.

May I thank your school for supporting me in my studies and I am confident that having commented on the proposed CAPS documents specific to mathematics in the Foundation Phase, our children are currently in a stronger position to make sense of number and gain true understanding of number concepts following the Singapore Mathematics Curriculum.

Yours in education

Bev Keth

APPENDIX D

4 B..... Road
S.....
Eastern Cape

12 October 2010

The Chairman of the **School B** Governing Body
School B **Preparatory School**
XXXXX

Dear X and members of the SGB

Re: permission to pursue my Masters in Education (Mathematics) at School B Preparatory.

The Governing Body of School B is very supportive of staff wanting to develop professionally and I thank you for this stance. The M Ed offered by Rhodes University Grahamstown, for which I have completed my first year course work, has afforded me the opportunity of submitting a proposal for my thesis which is awaiting the approval from Rhodes University.

As I research the role of teacher practice using the Singapore Mathematics Curriculum, using teachers from both School A (2 teachers) and our school B (4 teachers), I ask permission from the School Governing Body

1. To video extracts of mathematics lessons from teachers within the focus group. This will afford the teachers opportunity to share their expertise and become critical reflective practitioners as they contribute to the data within this research.
2. In addition, written permission will be requested from every parent of each class to share these tapes within a focus group.
3. As I endeavour to gain a broad and critical perspective on Mathematics Education in the context of my own personal space within School B and the Eastern Cape, I also need permission to divulge the name of the school when sharing current developments and comparing with global trends outside of my thesis work.
4. Confidentiality is guaranteed in my thesis and no teachers or girls names are used times and teachers make use of pseudonyms in my data analysis.

I am currently working with a focus group of volunteer teachers from both School A and School B. All meetings have taken place outside of school hours and the group meet at my home over the weekend. This will afford the teachers opportunity to share their expertise and become critical reflective practitioners as they contribute to the data of this research. May I thank you for affording me time to attend the compulsory course work on two occasions during the school term. All relevant study leave forms and letters were submitted to Mr K, my EDO in the DoE. In addition I have attended a conference on mathematics during the holiday in Johannesburg where I was invited as a guest. I have also presented a workshop at the invitation of School C and School D in Grahamstown over a weekend for all mathematics teachers interested in the Singapore Mathematics Curriculum.

May I thank the SGB for supporting me in my studies and I am confident that having commented on the proposed CAPS documents specific to mathematics in the Foundation Phase, our girls are currently in a stronger position to make sense of number and gain true understanding of number concepts following the Singapore Curriculum. The findings of my research will be available to all interested parties.

Yours in education

Bev Keth

APPENDIX E

Interview schedule for semi-structured interview with example of transcription from Teacher F

Interview introduction	Teacher F, Thank you so much for coming to chat to me today about maths and for being willing as a maths teacher, to share your expertise and experiences with me.
Interviewer	First of all, could I ask you just to share a little bit about the children in your class who you are actually teaching at this moment – maths specific?
T Response	I‟ve got um a class of 16 and I would say that the majority are above average. I have some that find maths more challenging, probably two of them and about four of those are pretty maths proficient.
Interviewer	And your most exciting experience with the children regarding the children and the SMC as an experience in your class?
T Response	They love being active in their maths lessons so they absolutely love it when we play games and think it‟s totally amazing. The one lesson specifically where they learnt a lot through a game form and when they got to their books they were all saying "I know how to do this – I know how to do this" and it was so exciting and I said you said so you see you learnt, you learnt through playing games and they thought that was really cool.
Interviewer	Can you share um what you feel about the different knowledge needed for teaching maths – maths specific and knowledge of children & how to teach?
T Response	I think it definitely helps to have a good maths general knowledge, um that could possibly come from when you are at school or through your studies. But keeping up to date with what is the latest reading things as well um.. What was the second part of your question?
Interviewer	How about the knowledge for teaching maths?
T Response	Ok. Yes and having a good understanding of your age group and how to keep children interactive all the time in the learning process – I would say – ya very important and to be able to maintain that throughout your lesson.
Interviewer	In one of your lessons in the SMC we saw a stunning approach to lesson planning and how it just worked for you – using the textbook, using the apparatus, can you just share a bit about your experiences of how you go about actually planning a SMC maths lesson.
T Response	When I go about planning I am obviously thinking about what I am trying to achieve as far as the maths concepts are concerned, but also where my children are at and to keep thinking how to challenge them so that all the time their interest is kept, so I‟m thinking those who are maybe weaker and are going to need some other form of repetition with a particular concept, but then I am also thinking about how I can challenge those who are very proficient in maths so I have to think about all of that when I am planning a lesson and how what I am going to achieve with them in the 50 minute maths lesson with them.
Interviewer	So the role of different tasks (Yes) in your lesson do you see that as very important?
T Response	Yes – to vary the tasks that the children are involved with so um when we are in the classroom we are not only working at our tables doing something on the carpet or maybe using our textbooks and using some apparatus and then applying what they have learnt in their books at their desks – so to keep a variety throughout the lesson so that all the time you are holding their attention and actually learning and proving what they have grasped.
Interviewer	And so the understanding comes (Yes) and your view as a teacher in the role of the teaching in maths.
T Response	Yes
Interviewer	And so you view as a teacher using the SMC what has been the most challenging – or

	what challenges have you found?
T Response	I think what I have found is that they have specific methods that they use and I have always liked to keep it totally open as far as what a child comes up with to how they solve a problem – whatever concept you are in, so um I first thought oh it‟s too much textbook or whatever um bound rather than letting the individual think for themselves, but with using it more over the years, you realise how much you actually can expand on things than what is just required for the day, because sometimes what is required for the day is actually pretty simple and pretty quick so I actually expand on that and make sure that the 50 minutes are absolute quality time in maths - that ja I try to achieve that at least 5 times in the week ha ha
Interviewer	And coming up with the solutions that you let the children come up with that is then filling a gap for you (Yes), in otherwise you would say, you can add more to.
T Response	Yes
Interviewer	Tell me when you talk about the children coming up with solutions do you feel it is more important to teach the understanding and the concepts of the maths or the ways they do it and the procedural fluency?
T Response	Definitely the understanding um & that is why in the lesson I am thinking about the abilities of the children all the time, so um allowing them the space to come up with the ideas gives them plenty of room for thinking for themselves and ..Um what was I going to say? Ya when you are trying to put the concept across that they are trying to make it for themselves. So yes following the methods and the procedures that they give in Singapore are sound and .. But giving them space to think for themselves and so therefore the understanding is more important method and once they have the understanding then they can use the method.
Interviewer	And I am glad that you mentioned the different tasks for them and the thinking that the children have to do – what kind of tasks - can you be a little bit more specific, practical, in the activities in a maths lesson that you have to do, to help children understand.
T Response	OK its using everyday manipulatives so you can use like stars and sticks and blocks and sucker sticks and those kinds of things where children use them for counting and various activities that you then can do which would give them something to actually look at within the concrete and then taking it from there further to use just the abstract.
Interviewer	So how do you think your students are actually learning, and how do you think they are actually gaining knowledge?
T Response	I think they are learning by each individual working with the concept that I am giving them and having the apparatus, having a whiteboard or koki or whatever and being able to interpret the concept in a written form because then that surely shows whether they have actually grasped something or not, so constantly posing problems to them, asking questions all the time and nobody is ever wrong, there is plenty of room, there is no mistakes and so they know that already in the class so they feel confident just to try.
Interviewer	So if no one is wrong – your whole idea of misconceptions that have maybe come up?
T Response	Then you would address that – so if there are misconceptions then you would need to clarify them and make sure they have thorough understanding of what was covered.
Interviewer	In multiplication you used a lovely way of checking the children to see that they fully understood what the groups were and therefore, you will take more of a direct role.
T Response	Yes That‟s true so when it comes to misconceptions, definitely the teacher is there to guide and lead so your role is definitely one of leading the children to thorough understanding
Interviewer	But otherwise a lot of facilitation (yes) from your side (yes)

T Response	Definitely that‟s why you are thinking of the child all the time and to keep them excited and interested and actually wanting to know what is coming next
Interviewer	And perseverance?
T Response	And Perseverance definitely plays a role um because it is equally exciting for me to see a child who is possibly battling with maths to finally have the a-hah moments but that is as important as those who are gifted in maths, so both sides need to um be achieving success and being challenged.
Interviewer	And with that the time factor for some who need extra time?
T Response	That‟s what I like about the SMC – the way they have set up things because each daily task has the homework that goes home with it, so it is completely specific, that is a big plus because teaching maths for quite a few years prior to that, you were drawing from all sorts of different resources from what you are doing. But you didn‟t always send homework home that was specific to the lesson that you taught. It would be something that was still relevant but not specific to a lesson, where Singapore, the way they have set it out is every single days homework, applies to what they have done which is fantastic and then also if there are children who are battling, I have given them a re-teach book which they work with their parents at home and they show me and so that child is given extra time with the resource that is available.
Interviewer	And the use of the actual workbook within the classroom? As a resource, how do you find that?
T Response	Now that is fantastic - and what happens is that, that is now a self-assessment for a child because now they do it on their own and quite often that is the quietest time because now they are on their own trying to see if they understand what needs to be done, so that is great.
Interviewer	I am glad you mentioned self assessment, tell me about the baseline tests that you do and the recognition of when they come up? How do you find these baseline assessments?
T Response	The baseline assessments have been good for us to see. And over the years the children (now that they have been in their third year of Singapore Maths have achieved better results than the previous years and they have actually been doing pretty well which is really nice, but one has been the Grade 5 (I did teach Grade 4 for one year) I want to mention that the one Grade 5 baseline assessment, we found extremely difficult for them.
Interviewer	And the spiral curriculum means there is a follow on throughout the Foundation Phase starting from the Grade R‟s and through. How important is it to understand the curriculum rationale across the grades for the teachers?
T Response	Now that is what is really fantastic about Singapore and is that it is a spiral curriculum and it does build upon and so, that is why with experience now the children who have been using Singapore longer are achieving better and as a result of those children now receiving the different concepts using the Singapore, where previously you were finding that you needed to play catch up with a few of the kids which now this is a way of solving that problem.
Interviewer	Teaching a curriculum is all about the teacher, different teachers, different teaching styles – how do you see the implementation of the curriculum using the SMC with all different teachers?
T Response	I think it has been a growth because a lot of people don‟t like change, so there are those who resist and maybe feel a bit anxious that they are not capable. But as time goes on and you share ideas then there is a definite plus factor but knowing

	we are all following the same system and the same thought in number concept specific to the Foundation Phase. It is really great having knowledge of what has happened, what you are currently teaching and where they are going and I think that that is the good thing about having the curriculum that is spreading right across all the grades.
Interviewer	What are the experiences you have had as being part of a focus group from two different schools and how have you found sharing your actual experiences and from others sharing their experiences with you from a SMC perspective?
T Response	Well I know from Teacher C and myself we have both discussed this and we have both said that the greatest thing of this all has been sharing with other teachers and from your studying uh the greatest thing we are taking away from this is what we have actually gained is from other teachers and their experiences and hopefully they can say the same.
Interviewer	Ok, so as a resource the focus group has been able to offer you greater insight?
T Response	Yes.
Interviewer	And what are some of the other resources, apart from the human resources of helping one another? Can you tell me some of the resources that you have particularly enjoyed in the SMC? Or has it been the same as you have always taught, using the same resources?
T Response	Are you talking specifically about the books and everything they have available in their manipulatives. Ok. The base ten blocks. I didn‟t, even from years of experience; I didn‟t put such a big emphasis on the use of them. But since using the SMC, it is just the best way to teach place value. So that is definitely a resource that has happened through SMC, and obviously the value of that specifically.
Interviewer	In the past, some people have questioned tricks, “gimmicks”, rules, would you like to comment where you see there is a problem or any area among SMC, where you would want to resort to “teach and tell”, rather than discover?
T Response	None in Grade one, two or three. When I taught Grade four, the division method of long division and long multiplication, the children didn‟t always understand it, because unfortunately that method is a lie and so for me it was then a case of going back and using the Base ten blocks over and over until they thoroughly understood what they were doing rather than just learning it, but there is a certain time factor and time frame that you have to get the child to the next grade and so you don‟t actually have enough time. So I can understand why some people do use tricks. Unfortunately that forgoes understanding, so some children go through learning method and they have no idea what they are doing and that is a tragedy, but I realise as a time factor, so even doing that with Grade fours, I was under a lot of pressure. Although I was trying to catch them up to understanding, there was pressure then to complete what needed to be done.
Interviewer	But you are in Grade 3 and for every child in your class, what are your aspirations for each of them using SM correctly?
T Response	First, would definitely be that they absolutely love working with maths, and working with numbers. So that the love of maths is huge, so if you have got that on your side you can help a child to gain understanding in mathematics. So to me that is definitely the first. The second would be to be thinking about the way they think, so why they are doing what they are doing, ya just to keep it an absolute pure joy with working with numbers.
Interviewer	And checking for children‟s understanding and their enjoyment, (Yes) do you feel that is an ongoing thing?
T Response	Yes, it‟s an ongoing thing, that‟s a daily thing, as well as a weekly thing. But there is that factor that the child is feeling that they are really achieving something and I can do

	this.
Interviewer	So where do you see Maths going using the SMC?
T Response	I think that children‟s problem solving is definitely improved and so I think that if schools follow this curriculum, they should see a greater level of achievement in Maths Olympiad‟s and those kind of setups that schools have and just you know, excellency of numbers. That surely must help us in absolutely everything in our country eventually.
Interviewer	And could that be achieved for you as easily without the curriculum?
T Response	For me, I‟ve always had a passion for Maths so I‟ve always had a problem solving approach in my teaching and always liked to bring the children in on the attitude towards Maths in a big way and a positive way, and so that wasn‟t much of difference for me personally. Just repeat your question.
Interviewer	So where do you see Maths going?
T Response	I think that South Africa could achieve way better in the TIMS that they hold every year. And maybe we are going to see many more problem solvers, people that you feel shouldn‟t just drop out, and to pursue the careers that require Maths.
Interviewer	And was a new curriculum possibly within our country? Have you given any thought to that versus what you are currently using?
T Response	The beauty of the SMC also is the fact that each lesson is so well formulated that teachers who perhaps don‟t have a good maths sense and are maybe not confident in teaching maths. If they follow what‟s given in the curriculum, they can be a very successful maths teacher.
Interviewer	And the Singapore Model Method that you use has that any comment, good or bad criticism?
T Response	Yes in the beginning, when I first started I was actually quite anti the model method because I thought this is now giving them a specific method that they don‟t understand. And so when we started the first year, they battled with it, but then children coming through had used it before did much better, now the third year even better, and so I have realised how they have learnt over time as well. And I really do believe it‟s a good place to be able to in a lesson draw what you are thinking and so a model method is a fantastic way to solve a problem that‟s visual. Ya, so it‟s a very good thing, and I‟ve since then pro the model, using it more often than what I would have in the first year.
Interviewer	And finally TF, can I just ask you if it is important to let children experience learning as a personal experience, allowing them the time to have control over their own thinking and gaining understanding?
T Response	Say that again.
Interviewer	Is it important to let children experience learning as a personal experience, allowing them to have control over their own thinking and gaining their own understanding, constructing their own knowledge?
T Response	Absolutely, I think that, that applies in any subject and it must be an individual thing because then the child is truly grasping what you are trying to put across, and you must grab their interest. And that means you are looking at each individual. So if you are not getting their interest, they are not going to want to learn, so the love of learning will come if they are being individually challenged.
Interviewer	And has this changed your teaching practice, just in summing up where you see it for the children? About mathematics and gaining their own understanding and constructing their own knowledge, has this changed you teaching practice or have you always felt this way?
T Response	I would say that the teacher is key – a passionate teacher
Interviewer	So you are taking any curriculum and saying giving it a passionate teacher who is

	passionate about maths, the curriculum could work if the teacher is the key?
T Response	I would say that the teacher is key because your passion will definitely rub off to the children, and I know that I have children writing “Maths rocks”, “School rocks” in their books, and that‟s over a few years, and that‟s because they are just loving what they are doing. I think maybe because of the passion that the teacher has as well, influences them and they influence each other, and they become excited about it together.
Interviewer	So without praising SMC, what has Singapore specifically done to make a change for children and yourself to sum up in one thing?
T Response	Singapore has made a change.
Interviewer	Have your children always said “Maths rocks”?
T Response	I‟ve had that happen a lot over the years without the SMC, so it must have something to do with the teacher perhaps because children have absolute love and I know some kids that are above me who are now like twenty years old, or older whatever, they say “ahh, I remember Grade 3” and how they loved the Maths. So definitely the teacher plays a big role.
Interviewer	And thank you for sharing, thank you for sharing in all aspect Teacher F.

APPENDIX F

4 B..... Road
S.....
Eastern Cape
5201

February 2011

Dear Parents in Teacher F's class,

I am currently studying towards my M Ed in Mathematics Education and writing a thesis on the implementation of the Singapore Mathematics Curriculum at two Eastern Cape schools. Mrs F has been part of my focus group over the past year. I have observed class mathematics lessons and we have shared her experiences both in teaching and in interviews.

We have had an incredible learning experience and both grown professionally whilst using the Singapore Mathematics Curriculum. Part of the Grade 3F teaching and learning has been captured on video and your children have enthusiastically participated in mathematics lessons.

Whilst the video recordings are intended as evidence in my analysis of data, I hereby request parental permission to show extracts of these lessons to professional bodies interested in mathematics education. The confidentiality of names is ensured including the name of the school and class teacher, which will not be revealed during any viewing.

Please would you be so kind as to respond to the attached letter. Thank you for your understanding and co-operation in this regard.

Yours faithfully

B D KETH
M Ed (Mathematics Education) Researcher,
Rhodes University, Grahamstown

_____***REPLY SLIP***_____

PERMISSION TO SHOW EDUCATIONAL VIDEO CLIPS

I, _____ parent / guardian

of Child's name: _____ in

Grade 3 hereby give permission for Mrs Bev Keth to show extracts of

video recording from a mathematics lesson in which my daughter

participated. I understand that the name of the school, class and pupils' names will not be revealed in any showing.

Name: _____

Signature: _____

Date: _____

APPENDIX G

Minutes of the initial meeting of the focus group on 28th August 2010

This was the first get together of the teachers (from school A and school B) who had shown an interest in being part of Mrs. Keth‟s research.

The layout for the introduction to her research was very professional. With colour coded files and a Power Point presentation.

The atmosphere was very relaxed and jovial as all the ladies present worked together. However the meeting was being held at a location off school premises to remind the ladies that this research was not part of the school system and that any levels of hierarchy were now null and void. Mrs. Keth reiterated this statement in her introduction speech as well as stating that, "there will be no judgment in the negative or the positive." She is here to evaluate the curriculum and its effect on best teacher practice and would value the teachers‟ opinions, thoughts and feelings, which would be written in their reflective journals or discussed in the focus group meetings.

Mrs. Keth explained to the teachers about the anonymity in this research. Each teacher will be known by a letter of the alphabet and the colour of her file and reflective journal. No real names would be used. The group questioned the dating of journal entries. The entire group agreed that dating entries would be a good idea, especially for when one reflects back through one‟s journal. Mrs. Keth reminded the group that this research was mathematic specific.

Initially the focus group was very quiet through the Power Point presentation where they were being introduced to Mrs. Keth‟s research ideas, readings and time frames. Mrs. Keth was explaining that this was our world and this research was going to be about her perspective about what was happening with mathematics in schools and the impact of SMC (Singapore Mathematical Curriculum) on teacher‟s practice.

Once the presentation started to discuss SMC (an area that the focus group are currently working with), they (the focus group) began asking questions about SMC (the re-teach book, the enrichment and the time factors involved in SMC).

The section in the presentation about different methodologies, for example, Social Constructivism, had the focus group getting anxious about terminology and having to know all this theory. However, they were soon put at ease when it was explained what the methods meant and that the teachers were implementing them in their classrooms without realizing it and their understanding of theory was not the focus of this research.

The group was asked to use the Kilpatrick Conceptual model of teaching for math proficiency as an analytical tool for their observations. This was followed by an interactive demonstration about each strand and how it is linked to foundation level mathematics in a practical way. These demonstrations put the focus group at ease and lightened the atmosphere, which had become very serious with the academic theories. The feeling amongst the group was that they now understood this theory in a more practical way. They could relate to it.

Mrs. Keth explained that as the researcher she is unable to do the teaching. That is where the focus group comes in. They will assist in the collecting of the data required for the research.

Each participant needs to sign a letter of willingness to participate (and at anytime can withdraw from the group). The participants were told of the possibility of being video-ed or that all report backs will be taped. These need to be kept as evidence. Individual permission would be obtained before video material or taped discussions were shared with the group.

Permission from the students‟ parents would also be required for the videoing and if work is shown to the focus group.

The group started writing down furiously when Mrs. Keth started discussing the reflective journal and what needed to be in it. She then agreed to if each member a photocopy of her slide, to prevent them writing down points and missing vital verbal information.

Mrs. Keth reflected on the limitations of her research (all lady teachers, no low economic schools and all white teachers.) She then explained the 4 stages of her research and what areas the focus group would be involved in and the time frames. When she got to Stage 4, the individual presentations, there were nervous giggles from the group.
Some of the focus group members aired their concerns that their teaching style would be compromised with the research or that they would have to change their methods to accommodate the collecting of data. They were also concerned about the previous knowledge of the students and their learning styles. Both these concerns were dealt with in a professional manner by Mrs. Keth. She doesn‟t want the Focus Group to change their styles / method and children‟s previous knowledge needs to be taken into account. This is their base for future learning. Also don‟t limit students through your grouping. The focus group appeared more at ease after their concerns were dealt with.
As the end of the meeting approached, one could see that it had been very taxing and long for the focus group.

Signed by independent teacher taking minutes:

APPENDIX H

Guidelines for teaching for mathematical proficiency

_____ 1. Encourages and accepts student autonomy and initiative.

_____ 2. Presents and encourages multiple perspectives and representations of concepts and content.

_____ 3. Uses manipulative, interactive and physical materials.

_____ 4. Uses cognitive terminology such as classify, analyse, predict or create when framing tasks.

_____ 5. Allows learner responses to drive lessons, shift instructional strategies, and alter content.

_____ 6. Responds to learner contributions.

_____ 7. Inquires about learners' understandings or concepts before sharing their own understandings of those concepts.

_____ 8. Encourages learners to engage in dialogue, both with the teacher and with one another.

_____ 9. Encourages learner inquiry by asking thoughtful, open-ended questions and encouraging learners to ask questions of each other.

_____ 10. Helps learners define, clarify, describe, and list examples.

_____ 11. Asks learners to elaborate on initial responses.

_____ 12. Avoids closed questions and narrow factual questions.

_____ 13. Engages learners in experiences that might bring about contradictions to their initial hypotheses and then encourages discussion.

_____ 14. Allows for "wait time" after posing questions.

_____ 15. Provides time for learners to construct and create metaphors and symbols.

_____ 16. Nurtures learners' natural curiosity.

_____ 17. Provides for learner self and peer evaluation of knowledge.

_____ 18. Questioning strategies require problem solving, analysis and reason.

_____ 19. Moves throughout room interacting with learners.

_____ 20. Serves as a guide, monitor, coach, tutor and facilitator.

_____ 21. Learning situations, environments, skills, content and task are relevant and realistic and represent the natural complexities of the "real world".

_____ 22. Facilitates scaffolding to help learners perform beyond the limits of their ability.

_____ 23. Allows for social interaction and knowledge sharing.

_____ 24. Learners' errors are taken into consideration and are used to gain insight into learners' previous knowledge constructions.

_____ 25. Assessment is authentic and woven into teaching.

_____ 26. Emphasises knowledge construction as opposed to reproduction.

_____ 27. Considers the learners‟ previous knowledge, beliefs and attitudes.

_____ 28. Favours collaborative and cooperative learning to allow learners to see others‟ Viewpoints.

_____ 29. Favours exploration by learners to construct their knowledge independently.

_____ 30. Emphasises problem-solving, higher-order thinking and deep understanding.

Adapted from (Evergreen State College, 2006); (Kilpatrick et al. 2001).

APPENDIX J

Collated answers to Questionnaire from Teachers A – F

SECTION A: ANSWERS TO TEACHER BACKGROUND INFORMATION

	TA	TB	TC	TD	TE	TF
FP TEACHING EXPERIENCE	11-20	>20	11-20	>20	5-10	11-20
QUALIFI CATIONS	Diploma 4year FP	Diploma	Diploma	Diploma	Degree in B Ed	Diploma HDE
1	3yr + 1 Gr R	20 yrs in Grade R/ Pre-Prim	9	12		1
2	13		4	5		2
3	0		3	3	7	11
SMC	2+	2+	3+ in Gr 2	2+ in Gr1	1+	3+
AGE	36-45	36-45	36-45	36-45	25-35	36-45
Current anxiety of chn	Little	A few have little	Some	Little	Some	Little
More or less than past	Less	Same	Yes more	No less	Yes more	No less
Personal belief & learning of maths	I was not very good at maths, but want children to enjoy doing maths	Loved maths, grasped easily, exciting T‟s + diligent homework		Tried to never let chn feel stupid – all about cu + concrete app	Struggled with new concepts,blaming poor teaching, relied on tricks & rules & little understanding	Maths is art in numbers. To think, act discover together
About yourself	My confidence has grown in understanding maths	An enquiring & analytical mind love PS & maths		Very negative re maths, I couldn‟t do maths,- Gr7 killer - embarrassment	As T real life situations, using concrete, acknowledges prior knowledge, T as facilitator to learning – sharing & discussing maths	

Adapted from “Implementing the National Council of Teachers of Mathematics *Standards*: A slow process” (Furner, 2004. p. 45)

APPENDIX J:
SECTION B: TEACHERS' ANSWERS TO VIEWS OF THE NATURE OF MATHEMATICS

1= strongly disagree, 2= disagree, 3= agree, 4 = strongly agree.

Question	Valence	Question relating to SMC	Rate 2010	Teacher comments
Problem Solving should be a separate, distinct part of the mathematics curriculum	negative	1	TA 1 TB 4 TC 2 TD 1 TE 1 TF 1	Should be integrated Part of all learning in Grade R NO (It is core to all aspects of mathematics)
Students SHOULD share their problem-solving thinking and approaches with other students	positive	2	TA 4 TB 4 TC 4 TD 4 TE 4 TF 4	They have a common way of sharing Interaction meaningful: (Collaboration & co-operative learning)
Maths can be thought of as a language that must be MEANINGFUL if students are to communicate and apply their maths productively	positive	3	TA 4 TB 4 TC 4 TD 4 TE 4 TF 4	Productive Disposition towards mathematics: TD = building a positive, confident attitude to maths is so vital)
4.A major goal of maths instruction is to help children develop the beliefs that THEY HAVE THE POWER to control their own success in mathematics	positive	4	TA 4 TB 3 TC 4 TD 4 TE 4 TF 4	 Grade R this is so important teacher feels building confidence & belief in themselves
Children should be	negative	5		Strategic competence different ways OK, be mathematically correct

encouraged to justify their solutions, thinking & conjecture in a SINGLE way			TA 1 TB 1 TC 1 TD 1 TE 2 TF 1	There is no 1 right way - 1 way is OK if it makes sense to them TD feels they may discover a more meaningful way for themselves TE = Conceptual Understanding for ANY WAY is essential TF = AT LEAST one way should be understood – if not more
The study of mathematics should include opportunities of using mathematics in OTHER CURRICULUM AREAS	positive	6	TA 4 TB 4 TC 4 TD 4 TE 4 TF 4	So valuable and worthwhile MUST BE relevant & relate to everyday life situations)
The mathematics curriculum consists of several discrete strains such as computation, geometry and measurement which can best be taught in ISOLATION	negative	7	TA 1 TB 2 TC 1 TD 1 TE 1 TF 1	NO it should be integrated in FoundationPhase It can be incorporated into other concepts for more understanding Taught all in conjunction
Learning maths is a process in which students absorb information, storing it in easily retrievable fragments as a result of repeated practice and reinforcement.	negative	8	TA 1 TB 3 TC TD 1 TE 4 TF 1	No LEARNING IS A PROCESS CONSTRUCTED IN THE MIND OF AN INDIVIDUAL Children don‟t just absorb, they discover then practice They take in so much in Grade R noting 3 parts i.e. absorption vs construction, memory “box”, as a result of practice...only?)
Mathematics SHOULD be thought of as a COLLECTION of concepts, skills and algorithms	negative	9	TA 2 TB 2 TC 3 TD 4 TE 4	NO No I disagree Not that simple

			TF 3	More than a collection – it includes ways to reason
A demonstration of GOOD REASONING should be regarded EVEN MORE THAN students‟ ability to find correct answers	positive	10	TA 4 TB 4 TC 4 TD 4 TE 3 TF 4	TD = sometimes difficult for Gr 1 to express)
Appropriate calculators should be available to all students at all times	positive	11	TA 1-2 TB 2 TC 2 TD 2 TE 3 TF 3	provided students have an UNDERSTANDING of how to solve a problem Not all the time in FP HOW TO USE and not just to work out, but an aid
Learning mathematics must be an ACTIVE PROCESS	Positive	12	TA 4 TB 4 TC 4 TD 4 TE 4 TF 4	
Children Enter FP with considerable mathematical experience, a partial understanding of many maths concepts, & some important mathematical skills.	Positive	13 (original 8)	TA 3 TB 2 TC 2 TD 3 TE ? TF 3	Depends on the home or pre-school attended Depends – not all in Grade R TB – 2 GROUPS = LOTS EXPOSURE VS MINIMAL INPUT (TD depending on home environment & pre-schooling experience) Never taught below Grade 3
In K-4 mathematics, skill in computation should PRECEDE word problems	Negative	14	TA 1-2 TB 2 TC 2 TD 1	NO Start with a word problem DEFINITELY NOT

			TE 2 TF 1	
In K-4 mathematics, INCREASED emphasis should be given to reading and writing numbers symbolically	Negative	15	 TA 2 TB 3 TC 3 TD 2 TE 3 TF 2	 Rather understand the value of number The older the more symbolic writing of numbers OCCURS Keep all grade building foundations

Adapted from the Standards Belief Instrument, (Zollman & Mason, 1992) as cited in (Furner, 2004, p. 56); (Kilpatrick et al., 2001) and (Webb & Webb, 2008).

APPENDIX J:

SECTION C: Questionnaire for teachers' rating of aspects of the Singapore Mathematics Curriculum.

1= strongly disagree, 2 = disagree, 3 = don"t know, 4 = agree, 5 = fully agree

Question	Rate	Topic
1		In teaching maths, one should follow a specific "flow" of lessons as per set manual.
	TA 4	
	TB 4	TB ON WHOLE, BUT SOME COULD BE DONE EARLIER
	TC 2	TC YES – dev of concepts NB, but sometimes own ideas better in getting across
	TD 5	Prior knowledge is NB in scaffolding
	TE 5	Especially to cover foundations, be FLEXIBLE for a specific student/concept
	TF 4	Does SMC cater for the different ways students learn?
2		Mathematics teaching & learning requires a concrete – pictorial – abstract approach for all topics
	TA 5	Definitely
	TB 4	Lots of concrete initially
	TC 2	Great for some, but some can work in abstract – don"t need all steps
	TD 5	As long as they grasp in concrete before moving on
	TE 5	absolutely
	TF 5	Most definitely
		(Does teaching each concept always require the use of concrete manipulatives before dealing with abstract maths – is this so in SMC?)
3		Logic is promoted in SMC & originality & creativity plays a lesser role
	TA 5	
	TB 3	TB PRE-SCHOOL CREATIVITY SO NB
	TC 2	Logic not at expense of creativity
	TD 4	
	TE 2	Games & ideas allow for creativity in T"s guidelines
	TF 4	
4		Problem orientation should be the core of teaching mathematics
	TA 5	
	TB 3	TB MORE INTRODUCTION TO NOS THAN PS, DISCUSSION ABOUT NB
	TC	
	TD 5	Solving a particular problem or finding a solution
	TE 5	

		TF 5	
5		TA 5 TB 2 TC 2 TD 5 TE 2 TF 5	The process and the correct product are both equally important No set process - recursive Process & understanding more NB than product Process more NB than product, by understanding & explaining you check answer. Understanding the process is key One must get the answer correct but understanding the process is more important Both crucial
6		TA 4 TB 4 TC 3 TD 5 TE 3 TF 5	Whilst doing mathematics, understanding the topic is the most important idea Topic = concept= maths thinking = understanding
7		TA 5 TB 4 TC 4 TD 5 TE 5 TF 5	Learning calculation techniques and procedures requires understanding In SMC YES, but old curriculum tricks & rules often taught without understanding Not just teaching a method but a process
8		TA 2 TB 4 TC 1 TD 3 TE 1 TF 4	In SMC formality & specific methodology take priority Specific can be put into different ways - flexibility From Pre-Prim looks that way Many ways to solve problems and come up with solutions NO Children must find their own solutions that display their own understanding Yes but with understanding – could be more room for different methods – algebraic vs algorithms in Gr 3 addition
9			One should always make sure to visualise aspects of mathematics

		TA 5 TB 5 TC 5 TD 5 TE 4 TF 5	Visualization KEY TO "SEE MATHS" Especially in the concrete
10		TA 5 TB 4 TC 5 TD 5 TE 5 TF 5	Teaching mathematics provides an excellent opportunity to promote the development of the pupil"s thinking Allows opportunities to discover, explore, explain & reflect
11		TA 5 TB 4 TC 2 TD 5 TE 5 TF 4	In SMC being able to communicate your thoughts verbally and on paper are NB I would never have said this before teaching using SMC – (previously doing not speaking) For assessment on paper, but verbal is vital for our YOUNG age group learners. But there are time constraints Is verbal enough (hence model method)
12		TA 2 TB n/a TC 1 TD 2 TE 1 TF 1	Practice and Drill – referring to bonds & multiplication specific within SMC Needs to be supplemented by the teacher in multiplication Pairing and counting in two"s as far as pre-prim = odds and evens NO provision for drill & practice in SMC, supplementing has to occur There is INSUFFICIENT place for practice and drill A lack of practice of tables and bond drill needs to be supplemented in class time

Adapted from (Pehkönen and Törner, 2004); (Webb & Webb, 2008); based on Singapore mathematics textbooks, "My pals are here".