IMPLEMENTING THE NATIONAL CURRICULUM STATEMENT: HOW IS INSTRUCTIONAL CAPACITY IN THE TEACHING AND LEARNING OF MATHEMATICS CONSTRUCTED, ORGANISED AND REPLENISHED IN SECONDARY SCHOOLS?

by

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DEDICATION

I dedicate this thesis to my wife, Petronilla Mutsei, my son, Kudzai, and my lovely daughter, Dianga.

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It is with great sincerity and appreciation that I want to acknowledge the following:

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously submitted it in its entirety or in part to any other university for purposes of obtaining a degree.

…… …….

SIGNATURE DATE

(Benard Chigonga)

ACRONYMS

ACE	Advanced Certificate in Education
AS	Assessment Standard
CAPS	Curriculum and Assessment Policy Statement
COLTS	Culture of Learning, Teaching and Service
CASS	Continuous Assessment
C2005	Curriculum 2005
DoE	Department of Education
FET	Further Education and Training
HEQF	Higher Education Qualification Framework
HoDs	Heads of Department
LO	Learning Outcome
LTSM	Learning and Teaching Support Materials
TLM	Teaching and Learning of Mathematics
MWC	Malamulele West Circuit
NCS	National Curriculum Statement
NQF	National Qualification Framework
OBE	Outcomes-Based Education
SGB	School Governing Body
SIP	School Improvement Plan
SADTU	South African Democratic Teachers' Union

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SUMMARY

A study was undertaken to explore what constitutes instructional capacity in the teaching and learning of mathematics (TLM), with a focus on how schools (as institutions of teaching and learning) integrate resources for a particular configuration of capacity to promote high achievement levels of Grade 12 students in mathematics. Data were collected in ten public secondary schools, mostly in a disadvantaged context, in the Vhembe District in Limpopo Province, South Africa. The study explores strategies for constructing, organising and replenishing instructional capacity in TLM. Five low- and five high-performing schools were selected, based on the pass rate in mathematics in high stakes examinations. The researcher observed lessons and interviewed ten Grade 12 mathematics teachers, ten principals, five curriculum advisors and a sample of forty Grade 12 mathematics students.

The research revealed that the capacity to encourage the new curriculum reform practices in TLM within different schools is often inadequate, and largely fails to compensate for organisational effects and arrangements that shape the capacity to create quality instruction in mathematics. However, high-performing schools were somewhat ahead of low-performing schools in terms of encouraging reform-oriented teaching and learning in mathematics. Recommendations include:

- Principals should initiate the development and implementation of a school-based clinical supervision programme through collaborative decision-making to promote a sense of ownership by all mathematics teachers. Such a supervision programme would enhance commitment and ensure that all efforts are unified towards improving the quality of TLM.
- There is a need for the DoE in Limpopo Province to coordinate teacher professional development workshops, where effective practising mathematics teachers model how they teach mathematics in the classroom, while other teachers observe.
- Context-based strategies to enhance student outcomes in mathematics should be devised, such as modelling good practice by effective teachers in terms of: lesson preparation; subject knowledge; pedagogic approach; assessment and monitoring of classroom practice, including direct observation of teaching by HoDs and principals.

It is proposed that attention to these issues, amongst others, would limit the impact of an unpromising context on student achievement levels in mathematics in high stakes examinations in the Vhembe District and elsewhere.

Key words

Instructional capacity; quality instruction; instructional culture; instructional programmes; instructional leadership; instructional unit; teaching and learning of mathematics.

CHAPTER 1

INTRODUCTION

This chapter serves to situate the problem under investigation. It highlights: the background to the study; the problem statement; research questions; significance of the study; definitions of terms used; and the structure of the thesis.

1.1 BACKGROUND TO THE STUDY

The successful accomplishment of any human endeavour is dependent, to a large extent, upon clearly defined aims and an understanding of why the task has to be done (Krathwohl, 2004). Children's experiences at school shape their character and prepare them for the future. Thus, what goes on in the school is of critical interest to the nation as a whole.

The role of education includes efforts to assist in solving social problems and in the reconstruction of society (Krathwohl, 2004). In an effort to assist education in fulfilling this function effectively, the post-apartheid government of South Africa has, since 1994, undertaken a number of initiatives to transform its education system. Xaba (1999:1) refers to the following examples of government's efforts to improve education: the enactment of the South African Schools Act 84 of 1996; the introduction of Curriculum 2005 (C2005) into the Foundation Phase in 1997; the devolution of administrative power from the national to the provincial departments; the launch of a culture of learning, teaching and service (COLTS); and most recently, the amendment of the National Curriculum Statement (NCS) Grades R-12, where the subject statements, learning programme guidelines and subject assessment guidelines for Grades R-9 and Grades 10-12 were repealed and replaced by the Curriculum and Assessment Policy Statement (CAPS) for Grades R-12 (January 2011).

At the time of the current study, NCS was the curriculum followed in schools. Even though the current study report might be released after CAPS is almost or completely implemented in schools, the focus of the study is still valid, as it shows how instructional capacity is constructed, organised and replenished in the teaching and learning of mathematics (TLM). CAPS came about as a result of the reorganisation of curriculum and assessment, that is, we note that the change from NCS to CAPS is characterised by the subtraction and addition of specific unit content and a reduction or addition in the number of assessment tasks within a school calendar year. For example, the introduction of Annual National Assessment (ANA) at

the end of foundation (Grades R-3), intermediate (Grades 4-6) and senior (Grades 7-9) phases and that probability in the FET (Grades 10-12) phase will no longer be part of an optional paper 3. Hence OBE remains the philosophical principle that underpins CAPS Grades R-12 and it thus informs the teaching and learning process.

Until 2005, assessment in the pre-independent and post-independent South Africa was largely dependent on examinations. Previously in South Africa, success in Grade 12 was largely dependent on the end-of-year examination performance. In 2006, a new curriculum (NCS Grades R-12), based on "the philosophy of outcomes-based education (OBE)", was introduced in Grade 10 with a view to having Grade 12 students write an end-of-year examination based on this curriculum in 2008. This philosophy rejects the old assumptions of the traditional theories that believe that students come to school as "blank slates" to absorb knowledge from the teacher. Instead, it advocates that every student is capable of learning, provided that s/he is immersed in the right environment for learning to take place. This is grounded in the three premises of OBE, namely:

- ❖ All students can learn, but not in the same way and not on the same day.
- ❖ Successful learning promotes more successful learning.
- ❖ Schools control the conditions that directly affect successful school learning. (Killen, 1999:13)

The NCS Grades R-12 represents a policy statement for learning and teaching in South African schools and OBE forms the foundation for the implementation of the curriculum. We should therefore think about what the three above-mentioned premises of OBE mean for us as secondary school teachers, if we are to ensure the successful implementation of the curriculum. However, it is equally important to realise that the OBE paradigm is informed by the following principles:

1. Clarity of focus:
    - Which learning outcomes (LOs) do we want our students to achieve? Do students know where they are going and what is expected of them?
    - Are we clear about how students will be assessed and against what assessment standards (AS) they will be measured? Do students know the criteria against which they will be assessed?
    - Is the content relevant to the students or will they, in fact, never use it again?

- Are we teaching students content purely for the sake of teaching content?

2. Design down:
    - Is there a clear picture of the expected learning? Have we planned all the steps "backwards" that are needed to get there?
    - Do the learning units link together and work towards achievement of the relevant outcomes?
3. Expanded opportunity for all students:
    - Are we planning for students to succeed? Or are we expecting some students to "fail"?
    - Has our planning taken into account that students learn differently? That is, that our students have different learning styles? Or is it a case of one-size-fits-all?
    - How flexible are we in terms of teaching and learning time? Are we taking into account the fact that, if the student is demonstrating constant effort and constant progress, s/he should be allowed more time?
    - Are we giving the student the opportunity to develop according to his or her own potential ─ and not the potential of others?
    - In our lesson planning, and in our teaching and evaluation, do we have an ultimate vision of where we are going with the students? (Killen, 1999:13)

OBE is the philosophical principle that underpins the NCS Grades R-12 and it thus informs the teaching and learning process. Therefore, with what has been alluded to above, the NCS Grades R-12 reflects a complex innovation. According to Nelson and Sassi (2007), such an innovation is characterised by three dimensions, namely: "changing of teachers' beliefs"; introducing "new teaching and learning methods"; and introducing "new curriculum materials". They go further to acknowledge that the combination of new instructional methods and accountability pressures put many (mathematics) teachers in a quandary when implementing the new methods, i.e. between striking a good balance between teaching mathematics facts and calculation procedures and also developing a good conceptual understanding of mathematics.

While the 2008 and 2009 low achievement levels in the matriculation examination nationally paint a depressing picture of uncertainty, various concerns have also been raised about the new curriculum's effectiveness regarding quality education provision in South Africa. While some schools in South Africa have taken full advantage of the new curriculum and policy

support to improve their capacity to offer quality instruction in mathematics, others continue to struggle and falter in their attempts to provide quality instruction to their students in mathematics, as reflected in low pass rates in high stakes examinations. For example, an analysis of November/December 2008 and 2009 matriculation mathematics examinations in the Malamulele West Circuit (MWC) reveals that: of the 306 candidates who wrote the examination in 2008, only 41.5% passed; and of the 328 candidates who wrote the examination in 2009, only 32.9% passed. The breakdown of the results is shown in Table 1.1.

Table 1.1: MWC 2008/2009 Matriculation Mathematics examination analysis

MARKS	YEAR		TOTAL
	2008	**2009**	
80-100	3	2	5
70-79	4	4	8
60-69	11	9	20
50-59	18	10	28
40-49	36	20	56
30-39	55	63	118
0-29	179	220	399
TOTAL	306	328	634

As can be seen in Table 1.1, it is evident that secondary schools in MWC are not able to offer quality instruction in mathematics to the majority of students. Of concern, then, is why our schools continue to fail in their pursuit of improving TLM, which in turn impacts on student performance. It is understandable, therefore, that the challenges militating against the successful implementation of the NCS Grades R-12 led to a review of the Curriculum in 2010 and the introduction of that CAPS in 2011. CAPS was developed for each subject (including mathematics) to replace the old subject statements, learning programme guidelines and subject assessment guidelines for Grades R-12.

In light of the exposed challenges, the main problem of this research will now be formulated.

1.2 PROBLEM STATEMENT

Focusing on what constitutes instructional capacity in TLM in the era of the new curriculum implementation, how is instructional capacity in TLM constructed, organised and replenished in public secondary schools in the Malamulele West Circuit?

This problem statement gives rise to a number of questions that summarise the main problem to be addressed by the present research.

1.3 RESEARCH QUESTIONS

1) What is the level of instructional capacity of mathematics teachers?
2) How do mathematics teachers identify, mobilise and activate resources for mathematics instruction?
3) What other challenges do mathematics teachers experience in the process of developing instructional capacity?
4) What contribution, if any, do students, principals of schools and mathematics curriculum advisors make to the development of instructional capacity?

To this end, the next section concerns the significance of the study.

1.4 SIGNIFICANCE OF STUDY

Reys and Lappan (2007) assert that because mathematics is a foundation discipline for other disciplines and grows in direct proportion to its utility, the curriculum should provide opportunities for all students to develop an understanding of mathematical models, structures and stimulations applicable to many disciplines. Therefore, the present study makes an important contribution.

In South Africa, parents, students, teachers, employers, professional mathematicians, tertiary institutions and cultural and political organisations are concerned about matriculation results. The Minister of Basic Education, Angie Motshekga, (quoted in the Periodical Teachers' News Letter, October 2010) revealed that Limpopo, KwaZulu-Natal and the Eastern Cape are home to the majority of the country's most dysfunctional schools, which recorded the worst pass rates in the 2009 matriculation examinations. Motshekga further indicated that a total of 506 schools across the country achieved pass rates between 0% and 20% in the 2009 matriculation examination. Limpopo tops the list, with 186 of these dysfunctional schools.

Therefore we, as teachers, should question our methods and, through research, seek novel ways of teaching that may increase our effectiveness and efficiency.

First, since the introduction of the NCS in the Further Education and Training (FET) band in 2006, apparently little attention has been given to generating information on the practice of constructing and developing an instructional capacity that supports quality instruction in mathematics. Such an instructional capacity would help inform mathematics classroom practitioners, who are the immediate implementers of the new curriculum. Furthermore, this study serves to inform the decision makers within the MWC, the district and the Department of Education (DoE) at large on how the new curriculum is being translated into action and how teachers' knowledge, perceptions and experiences impact on the (de)construction of capacity for quality instruction in TLM.

Second, how stakeholders understand and interpret this new curriculum is crucial to its implementation. In order to ensure the smooth running of the curriculum implementation, key players in the implementation of a change need to understand and acknowledge a need for change. On the other hand, lack of understanding often leads to misconceptions and misinterpretation of a situation. Reys and Lappan (2007) explain that policy development and implementation is a complex process that involves different actors at various levels. These are: developers (politicians) at the macro level; decision-makers at the middle level; and teachers and students on whom the policy has an impact at the lowest level. Reys and Lappan (2007) warn that the implication of having many actors in the process is that if it is not monitored carefully, implementation of the policy at school level might be interpreted differently from the intentions of its developers. In support of this view, it is hoped that the information generated by this study will inform those most closely involved of the nature of the constraints (if any) in coordinating implementation of the new curriculum reform among all stakeholders (teachers, curriculum developers, the examination board and the governing structures).

Third, although this student-centered education is being practised in many other countries in the world (e.g. Australia), there seems to be very little information available in developing countries concerning the effectiveness of the practice. The study will provide data on the numerous and complex factors that account for current constraints in the era of the new curriculum implementation in mathematics education. It is hoped that the presentation of the results to the authorities may be used to realign the objectives of in-service programmes and

teacher education programmes, making them more relevant and more suited to the new curriculum reform. Furthermore, the study will help to inform mathematics teachers about the instructional behaviours and practices of teachers that result in higher student learning gains. However, it should be noted that the aim of the present research is to break with the past in the approach taken to integrate a commitment to quality instruction with the demands of high-stakes testing. Therefore, the impression should not be created that the present research prescribes what is right. On the contrary, it is based on what is meaningful and worthwhile. It is within the optimistic spirit of future exploration that the study is presented, not as a final prescription of what mathematics teachers ought to do, but as an attempt to reveal what might be necessary to enhance the culture of TLM in schools.

1.5 EXPLANATION OF KEY TERMS

Below are important terms used in the study.

1.5.1 Instruction

Instruction refers to the arrangement of an environment (media-presented information) in an effort to maximise the probability that students interacting with this environment will learn what the instruction intends (Dick & Carey, 1996). At the very least, effective instruction includes the following basic components which are events that occur as part of an instructional sequence in terms of the action of the teacher and fits in well with the constructivist approach:

- ✓ Pre-instructional activity
  - Motivation (gain attention of the students to ensure reception of coming instruction by giving the student a stimulus)
  - Objectives (tell students what they will be able to do because of instruction)
  - Entry behaviours (ask for recall of existing relevant knowledge such that each new skill learned should build on the previous acquired skill)
- ✓ Information presentation (present stimulus material/display content)
- ✓ Student participation
  - Practice (provide student guidance and ask the student to respond, demonstrating learning)
  - Feedback (give informative feedback on students' performance)

- ✓ Testing (summative evaluation is used to judge the effectiveness of the instruction)
- ✓ Follow-through
  - Remediation (require more student performance, and give feedback, to reinforce learning)
  - Enrichment (enhance retention transfer by providing varied practice to generalise the capability) (Dick & Carey, 1996:112).

1.5.2 Outcomes-based education

OBE is informed by the philosophy of social constructivism. Students discover and build understanding for themselves by engaging with activities alone and with other students, with the teacher as a mediator of learning (Le, Lockwood, Stecher, Hamilton & Martinez, 2009). The essence of the approach is to encourage the student to learn through interacting with his/her physical and social environment and in turn be able to demonstrate what s/he has learnt by sharing ideas, helping one another, working on joint projects, discussing, debating, testing and modifying his/her ideas against those of others. It is student-centered, i.e. instruction is designed to engage students as active participants in their own learning, and seeks to enhance the development of complex cognitive skills and processes (Le *et al.*, 2009). OBE is one of the central principles underpinning the NCS and the subject Mathematics fits in well with the OBE approach. "OBE has been selected as the most likely educational methodology to equip students for life" (Le *et al.*, 2009:24) in the South African democracy. In other words, the OBE system places the focus on what the students should be able to do, whereas under the old education system, the focus was on what the teacher should teach. The approach is reflected in the "Critical and Developmental Outcomes of the NCS". The approach sets the LOs (the knowledge, skills and values) and focuses on the achievement of the outcomes. Its student-centered, activity-based approach aims to make learning relevant and effective.

1.5.3 Instructional culture in schools

The instructional culture in a school is: the nature and content of the professional community; the collaboration among teachers; collective and shared goals for teaching and learning mathematics; and the opportunities for students and staff to exert an influence on the teaching and learning at their school (Newman, King & Youngs, 2000).

1.5.4 Instructional programmes

Instructional programmes focus on clear and specific learning goals of the mathematics teachers within the school.

1.5.5 Instructional leadership

Instructional leadership is the leadership influences on the mathematics teachers emanating from both inside and outside the school. McEwan (1998:10) defines an instructional leader as an individual whose behaviour is officially designated by the school and directly affects the teachers' behaviour to facilitate students' learning and achieve the goals of the school. When defining the principal as an instructional leader, McEwan (1998:10) refers to Jones (a principal for eight years), who was passionate about his philosophy of instructional leadership:

> To be an instructional leader, you must be a person who eats and sleeps teaching and learning. Instructional leaders must constantly think about how to organise school and instruction so all children can learn.

According to Bush, Joubert, Kiggundu and Van Rooyen (2008), the principals in highly productive schools are not only educational managers, but also instructional leaders. This is because these principals spend more time in direct classroom supervision and teacher support.

McEwan (1998:10) defines the role of the principal as an instructional leader as "… directly related to the processes of instruction where teachers, students and the curriculum interact".

In the present research, the role of an instructional leader is to create a culture conducive to TLM, or a culture where teachers, students and parents work together to accomplish the task of education (McEwan, 1998:6).

1.5.6 Instructional unit

An instructional unit comprises the teacher, the students and physical and intellectual materials.

1.5.7 Quality instruction

Quality instruction is designed to engage students as active participants in their own learning and seeks to enhance the development of complex cognitive skills and processes.

1.5.8 Instructional capacity

Instructional capacity is the means or tools available and mobilised by a school in its quest to offer quality instruction or foster quality learning for all mathematics students.

1.5.9 The school's capacity

The school's capacity consists of the individual teacher, the instructional culture, the instructional programme, the nature of instructional leadership and the quality of technical or material resources (both physical and intellectual) for teaching and learning (Newman *et al.*, 2000).

1.6 STRUCTURE OF THESIS

The purpose of this research is to explore high and low achieving secondary schools in the Vhembe District of Limpopo Province. The focus is on what constitutes instructional capacity in TLM in the era of the new curriculum implementation to enhance a culture of TLM in schools. The structure of the thesis is as follows:

i. The present chapter situated the problem under investigation. It comprises: background to the study; problem statement; research questions; significance of the study; and definition of terms.
ii. In Chapter 2, the researcher provides the theoretical background regarding the nature of a school's capacity that is likely to shape instruction and learning in mathematics. The theoretical background attempts to reveal the critical roles of students, educators, the instructional leadership and other stakeholders in the (de)construction of the school's capacity to offer quality instruction. The theoretical background is used to identify strategies that could be employed to develop an account of how instructional capacity in TLM is constructed, organised and replenished in a secondary school under the new curriculum.
iii. Chapter 3 concentrates on the research design, sampling, the development of research instruments and reliability and validity in qualitative research. This chapter also

addresses content validity of the data collection instruments, as well as the pilot study. It also highlights data collection strategies based on the various principles developed in the framework of instructional capacity and, finally, potential ethical dilemmas.

iv. Chapter 4 concerns data analysis and interpretation.

v. Chapter 5 is a discussion and implications of the research findings.

vi. Chapter 6 is a summary of the study, the conclusions derived from the study and the recommendations on how to construct, organise and replenish instructional capacity in TLM in schools.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A literature study can be defined as an extensive, exhaustive, systematic and critical examination of publications relevant to the research project (Lobiondo-Wood & Haber, 2006). A thoughtful and insightful discussion of the related literature helps to build a logical framework and also contextualises the research within a tradition of enquiry and a context of related studies (Marshall & Rossman, 1995:3).

The literature review is significant in guiding and planning the whole research project. It determines whether or not the researcher's endeavours are likely to add to existing knowledge in a meaningful way (Ary, Jacobs & Razavieh, 1990:67). According to Ary *et al.* (1990), knowledge in any given area consists of the accumulated outcomes of numerous studies conducted by generations of researchers. One should therefore review the literature for purposes of finding a link between one's own research and the accumulated knowledge in one's field of interest. Marshall and Rossman (1995:3) emphasise that the literature review should indicate that the research will fulfil a demonstrated need in a particular field. A research project with no link, or one that is not rooted in the existing literature will produce fragments of information that are of limited use (Ary *et al.*, 1990:67). If the research questions are too broad or vague to be put into practice, a careful review of the literature helps the researcher to alter and revise the preliminary questions so that the theme can be easily investigated (Ary *et al.*, 1990:67).

Furthermore, the literature review assists the researcher in choosing the appropriate methods (Strauss & Corbin, 1990:51). In addition, the exposition of the findings and the recommendations made as a result of the research are guided by the literature review and it is therefore used to support the validation of the accuracy of the research findings (Lobiondo-Wood & Haber, 2006).

The present research examines the process of identification, mobilisation and activation of resources for instructional improvement in mathematics with a view to constructing instructional capacity in TLM in schools. The purpose of this chapter is to determine what instructional capacity is and how it enhances the achievement of specific instructional goals

in mathematics within the school environment. In this chapter, a description of instructional capacity is presented as a framework for bringing together, in a dynamic way, the investigations of classroom processes and the school-wide organisational resources and arrangements that are set to promote quality teaching and learning at all times. In accomplishing this, the five key dimensions that are likely to shape instruction and learning in a school will be studied in depth. These key dimensions at school level are: the individual teachers; the instructional culture; the instructional programmes; the nature of the instructional (principal) leadership; and the quality and quantity of technical or material resources for teaching and learning (Corcoran & Goertz, 1995).

While investigating possible causes of defects in the capacity to offer quality instruction in TLM, it is necessary to consult a wide range of literature about NCS and OBE (the teaching philosophy that underlies NCS) with respect to: the purposes and principles, the inter-connectedness of communication (questioning and feedback), assessment and TLM within the OBE paradigm. By so doing, an attempt will be made to reveal what might be considered necessary for teachers of mathematics, students and principals to enhance the culture of TLM in schools.

2.2 INSTRUCTIONAL CAPACITY

2.2.1 The notion of instructional capacity

Instructional capacity is prominently featured in the contemporary conversation about education reform. This capacity is widely regarded as critical to good teaching and learning. Though reformers have frequently aimed to improve what students learn, most efforts to increase learning have concentrated on the following factors: improving curriculum materials, training teachers in new methods, or adding new technology (Cohen & Ball, 2006). Following this logic, reformers seem to have assumed that increasing the instructional capacity of schools depends on increasing the capacity of either teachers or the materials they use. There is increasing evidence that such efforts rest on very partial conceptions of instructional capacity (Cohen & Ball, 2006).

Some uses of the term “capacity” focus on space and storage, while others focus more on growth and change (Cohen, Rauden & Ball, 2003). In the first case, capacity denotes a finite set of knowledge, skills and commitments that are needed in order to produce good instruction; but in the second it denotes the construction of new knowledge and skills in

practice (Cohen, Rauden & Ball, 2003). Though much instruction lies somewhere between these two poles, they represent two quite different conceptions of the relationship between knowledge and practice - and thus instructional capacity (Cohen, Rauden & Ball, 2003).

Roughly speaking, the first view envisions capacity as a storehouse that contains fixed resources needed for instruction. These include: teachers' subject matter knowledge, skills and commitment, their knowledge of students, and the content of instructional technologies (Cohen & Ball, 2006). From this vantage point, having capacity refers chiefly to the extant body of teachers' knowledge and skill, the content of instructional technologies, and the adaptation and application of that knowledge in particular situations (Cohen & Ball, 2006).

In the second view, however, capacity is envisioned as a source and creator of knowledge and skills needed for instruction (Cohen & Ball, 2006). Teachers would improve practice by investigating teaching and learning, either *in situ* or in situations that derived from practice (Blank, De las Alas & Smith, 2008). Rather than only drawing on or delivering a fixed stock of knowledge, teachers would learn from practice in ways that generate more resources for subsequent teaching. They would learn about how students think about particular ideas, how certain representations of content work, what some common difficulties are that students encounter, and ways to mediate those difficulties (Barnett-Clarke & Ramirez, 2009).The study is premised on the notion of "instructional capacity" as a framework for bringing together, in a dynamic way, the investigations of "classroom processes" and "the school-wide organisational resources and arrangements" that are set up to promote quality teaching and learning.

As mentioned above, Corcoran and Goertz (1995:29) identified, among others, five key dimensions that are likely to shape instruction and learning in a school, i.e.: individual teachers; instructional culture; instruction programmes; the nature of the instructional (principal) leadership, and the quality and quantity of technical or material resources for teaching and learning. These capacity dimensions begin to define what I call the "capacity for (quality) instruction inventory", that is, the means or tools available and mobilised by a school in its quest to offer quality instruction or foster quality learning for all students in a specific subject area. This ability to offer quality instruction in a subject area is, however, determined not only by the presence or absence of particular resources, but also by the construction and organisation of such resources and their use by the various school participants and their maintenance or replenishment. That is, instructional capacity involves

identifying or defining, mobilising and activating particular sets of resources to achieve the specific goals of instruction in a subject area within the school.

2.2.2 The dimensions of instructional capacity

2.2.2.1 Individual teachers

Teachers constitute an important dimension of a school's instructional capacity. In recent years, there has been renewed interest in the role of the teacher as the key to school improvement (Nelson & Sassi, 2007; Wiliam, 2008). To a large extent, this transition is grounded in the realisation that any significant improvement in schools and in student learning must have the teacher as the centre-piece (Van Tassel-Baska, 2005). It is the "intellectual ability, knowledge and skills" of the individuals involved in the teaching and learning tasks that impact on job performance and effectiveness in the classroom (Heck, 2007). It is thus not only the presence or absence of teachers that makes a difference, but also the teachers who are competent in content, pedagogy and assessment of their subject area (Stronge, 2007:38). On the other hand, teacher effectiveness is an individual resource that varies across classrooms within a school, as well as a collective resource that varies across schools (Heck, 2009); research-based classroom instructional strategies and effective forms of professional development should reduce those variations to the point that every teacher ensures that no child is left behind (Lee, 2007).

However, the introduction of OBE and C2005 was an unprecedented curriculum reform in the history of South Africa. There was a huge gap at the time between the aims of OBE and C2005 and what the majority of teachers had been trained for (Jansen & Taylor, 2003). It was a challenge for many South African teachers who had inadequate knowledge, skills and competence and who relied on teacher talk and rote memory as the predominant mode of teaching and learning (Jansen & Christie, 1999). Because OBE differs from previous practice, one would imagine that intensive and extensive professional teacher development would be necessary to prepare teachers for the implementation of OBE (Fiske & Ladd, 2004); yet training of teachers for OBE was far from adequate (Jansen & Christie, 1999; Jansen & Taylor, 2003; Taylor & Vinjevold, 1999). Rather than mount a costly and complex series of professional development programmes, that engages teachers in learning activities that are supportive, job-embedded, instructionally focused, collaborative, and ongoing, the DoE introduced a "cascade" model through which teachers were trained and in turn had to pass their knowledge on to their colleagues. Teachers frequently complained that even the district

trainers themselves did not always understand the curriculum. The result has been the "watering down or misinterpretation of crucial information" (Fiske & Ladd, 2004:162). Does professional development lie at the heart of every educational effort to improve teaching and learning? Villegas-Reimers (2003) emphasises the relationship between educational reform and professional teacher development and adds that:

> Currently in the world, most societies are engaged in some form of educational reform … Regardless of the scope of the reform, the relationship between educational reform and teachers' professional development is a two way, or reciprocal, relationship … educational reforms that do not include teachers and their professional development have not been successful. Professional development initiatives that have not been embedded in some form of structures and policies have not been successful either (p.24).

Loucks-Horsley, Stiles, Mundry, Love and Hewson (2010:349) consider professional development a key element in sustaining a program of any kind in any subject area for many reasons, including: (1) the thinking about teaching and learning changes with new research; (2) curriculum innovations reach the market; (3) new ideas about science and societal issues influence what is important; and (4) perhaps most important, new teachers continuously enter the system. However, many models of professional development do not achieve their ambitious learning goals, yet professional development is "viewed as a critical component of reform, one that must be linked to those same clear goals for students, as well as assessment, pre-service teacher education, school leadership, and resources and staffing" (Loucks-Horsley *et al*., 2010:78).

When is teacher professional development relevant? In any meaningful professional development, teachers' learning should be sequenced over time (Loucks-Horsley *et al*., 2010:78). The research on change that describes and anticipates how teachers' needs change over time is helpful to guide the cycle of professional development implementation (Easton, 2009). Different strategies could be more appropriate for people depending on where they are in the change process. For example, at the beginning of the process, teachers may need concrete information first about what they will learn and its purpose. As they learn, they want more how-to advice and images of what the practices look like in real classrooms. Later, they want ways to collaborate with others on the use of the practice and to assess the impact on students (Easton, 2009). Also, Hunzicker (2011:178) suggests that effective teacher professional development should be:

- *Supportive*: it considers the needs, concerns and interests of individual teachers along with those of the school.
- *Job-embedded:* making it relevant and authentic.
- *Instructionally focused:* which involves the study and application of content and pedagogy with emphasis on student LOs.
- *Collaborative:* engaging teachers in both active and interactive learning.
- *Ongoing*: a combination of contact hours, duration and coherence.

With these characteristics of professional development in place, teachers are more likely to consider it relevant and authentic, which is more likely to result in teacher learning and improved teaching practice (Hunzicker, 2011).Therefore, teacher professional development becomes relevant when it connects to teachers' daily responsibilities and becomes authentic when it is seamlessly integrated into each school day, engaging teachers in activities such as coaching, mentoring and study groups (Hunzicker, 2011). To this end, discussion of traditional and alternative modes of professional development of teachers is necessary.

a) Traditional paradigm of professional development

Traditional professional teacher development, often called in-service training or staff development, has been conducted for different purposes and in different forms. Villegas-Reimers (2003:108) identifies four categories of in-service education based on purpose, i.e.: (1) for the certification of unqualified teachers; (2) to upgrade teachers; (3) to prepare teachers for new roles; and (4) curriculum-related dissemination or refresher courses. Regardless of the purpose, traditional in-service education/teacher professional development programmes are delivered in the form of workshops, seminars, conferences or courses (Ball & Cohen, 1999; Collinson & Ono, 2001; Feiman-Nemser, 2001; Fullan & Hargreaves, 1996; Schwille & Dembélé, 2007; Villegas-Reimers, 2003; Vonk, 1995). These efforts have been criticised by many researchers as being brief, fragmented, incoherent encounters that are decontextualised and isolated from real classroom situations (Ball & Cohen, 1999; Collinson & Ono, 2001; Feiman-Nemser, 2001; Fullan & Hargreaves, 1996; Villegas-Reimers, 2003; Vonk, 1995).

"We know it is important to keep professional knowledge and skills up to date, and presentation-style workshops are an efficient way to accomplish this. However, 'one shot', 'sit and get' workshops are becoming less effective in today's busy world. Much of the

information gained is not likely to be remembered, and even less is likely to be applied once we return to our daily routine. Re-conceptualising professional development to align with the needs of adult learners allows us to shift our efforts from a 'one shot', 'sit and get' model to one where teacher learning becomes part of daily routine" (Hunzicker, 2010:177). It is important to keep in mind that professional learning occurs within people who live and work in unique contexts that can either thwart or support professional development (Blank, De las Alas, & Smith, 2008). With reference to the traditional approaches to professional teacher development, Fullan (1991:315) states the following:

> Nothing has promised so much and has been so frustratingly wasteful as the thousands of workshops and conferences that led to no significant change in practice when the teachers returned to their classrooms.

In many developing countries, professional teacher development has been neglected because of budget constraints and heavy emphasis on pre-service education, but when it is provided, the cascade approach is popular for reaching many participants in a short time (Leu, 2004). The cascade or "multiplier" approach transmits the knowledge or information from the top to the lower stratified groups of teachers. This consequently entails "training the trainer" to ensure that the message "flows down" from experts and specialists to teachers. A teacher cohort is given short training courses and the teachers are then required to pass on their knowledge and skills to other teacher cohorts through formal courses (Peacock, 1993).

The advantages of the cascade training model are that it allows for training in stages, so that progress can be monitored and information can be disseminated quickly to a growing number of teachers as more and more teachers receive training. In theory, cascade training is cost effective, as those who have been trained can then train others, thus limiting expenses. They are run as centralised workshops or programmes and can be "an effective strategy to transmit messages about aspects of educational reform" (Leu, 2004:2). However, the intended message will not cascade down to lower levels without the appropriate mechanisms and support to ensure multiplication (Fiske & Ladd, 2004). Some disadvantages of this training model are that: it has a positivist approach to learning as its base; teachers are trained to follow patterns; the workshops have little inclusion of teacher knowledge and realities of the classrooms resulting in passive learning; and its goal is to have teachers who are competent in following rigid and prescribed classroom routines (Leu, 2004:6).

b) Alternative paradigm of professional development

In the 1990s, the rise of a constructivist approach to learning, coupled with criticism of traditional teacher professional development efforts, led to an alternative paradigm of professional development. The alternative paradigm of professional development is a school-based model and teacher facilitated (with support materials) in which all teachers participate. This paradigm is likely to be more effective because it is often led by current classroom teachers, whom other teachers trust as a source of meaningful guidance on improving teaching (Blank *et al*., 2008).

The goal of an alternative paradigm of professional development is to have teachers who are reflective practitioners who can make informed professional choices. Villegas-Reimers (2003:203) suggests that a new perspective of professional development should be:

- based on constructivism;
- perceived as a long-term process;
- perceived as a process that takes place within a particular context;
- intimately linked to school reform;
- conceived as a collaborative process; and
- very different in diverse settings.

Professional development experiences that share all or most of these characteristics can have a positive influence on teachers' classroom practice and student achievement (Villegas-Reimers, 2003). According to Hiebert *et al.* (2002:15):

> Research on teacher learning shows that fruitful opportunities to learn new teaching methods share several core features, i.e.: (a) ongoing (measured in years) collaboration of teachers for purposes of planning, with (b) the explicit goal of improving students' achievement of clear learning goals, (c) anchored by attention to students' thinking, the curriculum, and pedagogy, with (d) access to alternative ideas and methods and opportunities to observe these in action and to reflect on the reasons for their effectiveness.

Thus, there is consensus in the research community about "what" constitutes effective teacher professional development. However, the rift between the rhetoric and reality remains wide (Collinson & Ono, 2001; Hiebert *et al.*, 2002; Villegas-Reimers, 2003; MacNeil, 2004:4; Schwille & Dembélé, 2007). Regarding the rift between the rhetoric and reality, MacNeil (2004:4) asserts:

> The knowledge gap … is not so much about knowing what good professional development looks like; it's about knowing how to get it rooted in the institutional structure of schools.

Re-conceptualising professional development to align with the needs of adult learners allows us to shift our efforts to a model where teacher learning becomes part of the daily routine. The checklist in Table 2.1 (whether used as a planning tool, an in-progress survey or a final evaluation) serves as a guide for designing professional development that is more meaningful for teachers than a 'one shot', 'sit and get' presentation-style workshop (Hunzicker, 2011).

Table 2.1: Effective professional development for teachers: a checklist (Hunzicker, 2011).

	Yes	Partly	No
Supportive			
• Does it combine the needs of individuals with school/district goals?			
• Does it engage teachers, paraprofessionals and administrators?			
• Does it address the learning needs of specific schools, classrooms, grade levels and /or teachers?			
• Does it accommodate varying teaching assignments, career stages and teacher responses to educational innovation?			
• Does it accommodate individual learning styles and preferences?			
• Does it integrate teacher input and allow teachers to make choices?			
Job-embedded			
• Does it connect to teachers' daily responsibilities?			
• Does it include follow-up activities that require teachers to apply their learning?			
• Does it require teachers to reflect in writing?			
Instructional-focus			
• Does it emphasise improving student LOs?			
• Does it address subject area content *and* how to teach it?			
• Does it help teachers to anticipate student misconceptions?			
• Does it equip teachers with a wide range of instructional strategies?			
Collaborative			
• Does it engage teachers physically, cognitively and emotionally?			
• Does it engage teachers socially in working together toward common goals?			
• Does it require teachers to give and receive peer feedback?			

Ongoing

- Does it require a high number of contact hours over several months?
- Does it provide teachers with many opportunities to interact with ideas and procedures or practice new skills over time?
- Does it build on or relate to other professional development experiences in which teachers are required to engage?

Another guide for designing professional development is the Concerns-Based Adoption Model (CBAM), which describes the emerging questions or concerns that teachers have as they are introduced to and take on new programs, practices or processes (Easton, 2009). These concerns develop from questions that are more *self-oriented* (e.g., "What is it?" "How will it affect me?" and "What will I have to do?") to those that are *task-oriented* (e.g., "How can I get more organised?" "Why is it taking so much time?" and "How can I best manage the materials and schedules?"), and finally, when these concerns begin to be resolved, to more *impact-oriented* concerns (e.g., "How is this affecting students?" and "How can I improve what I am doing so all students can learn?") (Easton, 2009).

This model suggests that teacher concerns can guide the selection of strategies for professional development and provide insight into the content of the strategies in order to adequately address teachers' needs and concerns as they go through the change process (Easton, 2009). For example, if the goal of the professional development is to increase teachers' content knowledge so they can provide more enquiry or problem solving approaches in mathematics classes, the designer might choose to first offer teachers an immersion experience in mathematics and then workshops that help raise teachers' awareness of what new teaching practices look (and feel) like in action (Loucks-Horsley *et al*., 2010: 163). As they practice new moves in their classrooms, they need opportunities to meet with other teachers to discuss what is working and how to make refinements. Through this, they increase their understanding and their skills (Loucks-Horsley *et al*., 2010).

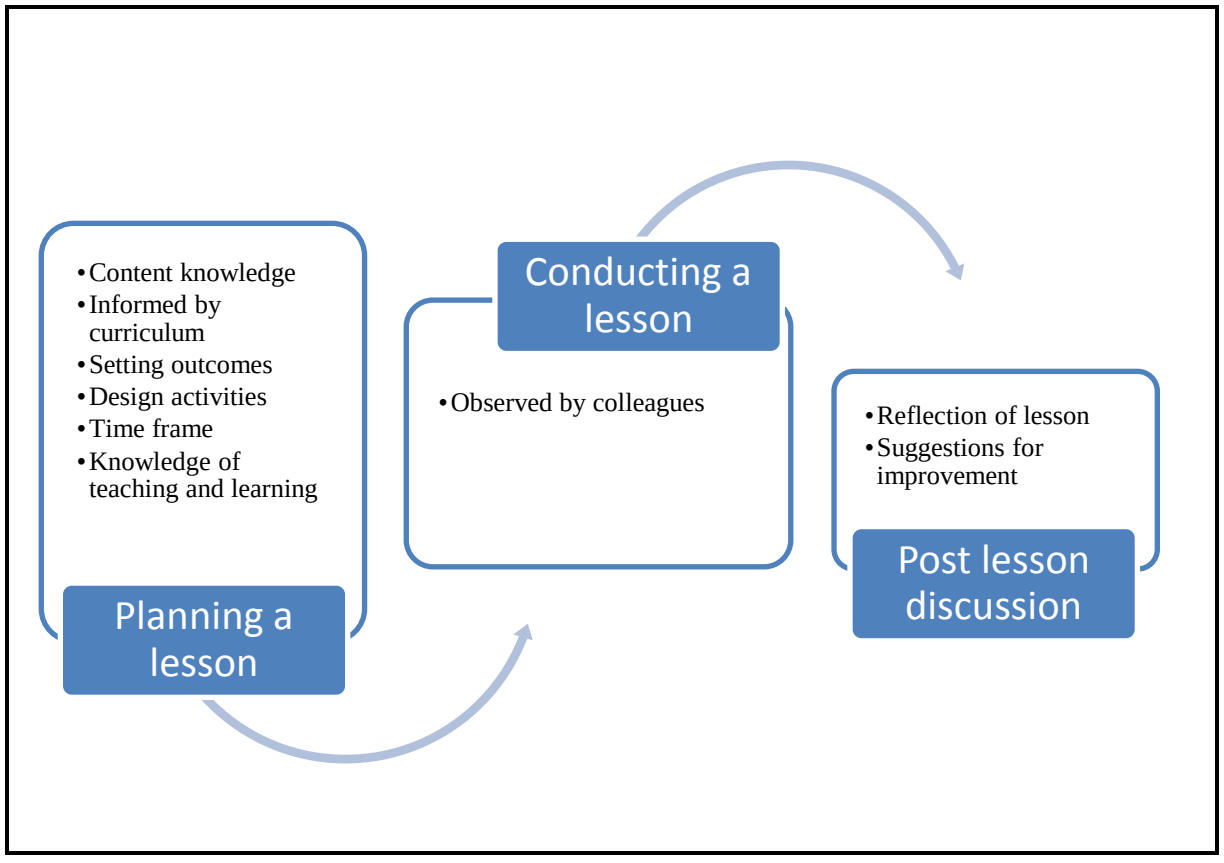
More *impact-oriented* questions of teachers can be addressed through opportunities for them to examine student work or to conduct action research into their own questions about student learning. During these latter stages of learning, teachers are often engaged in examining their experiences in the classroom, assessing the impact of the changes they have made on their students, and thinking about ways to improve (Loucks-Horsley *et al*., 2010). At this point in

their learning, teachers also reflect on the practice of others, relating it to their own and generating ideas for improvement (Loucks-Horsley *et al*., 2010), which are characteristics similar to those of lesson study.

What is lesson study? Lesson study is a type of classroom research in which a few teachers investigate teaching and learning in the context of an actual single class lesson (Lewis, 2008). When the teachers complete the study, they document their work in a report that describes the lesson they designed and explains how the lesson worked and what they learnt about teaching and learning from the lesson study experience.

The most salient feature of lesson study is that teachers are collaboratively engaged in action research in order to improve the quality of instruction (Ono, 2008*)*. Figure 2.1 depicts the lesson study cycle.

Figure 2.1: Lesson study cycle (Adapted from Ono, 2008*)*



The three phases of lesson study, as shown in Figure 2.1 above, are collectively referred to as "plan-do-see" (Ono, 2008). The planning phase begins with selection of the topic and encompasses the study of teaching materials and the mapping out of lesson plans.

The process of lesson study is initiated by setting a goal. The teachers work collaboratively to achieve this particular goal (Ono, 2008). The study of teaching materials is believed to help teachers clarify unclear points and to confirm and strengthen the content knowledge necessary to teach the topic effectively (Kazemi, Lampert & Ghousseini, 2007). Mapping out lesson plans requires teachers to have a good understanding of their students' needs, pre-knowledge and misconceptions. Teachers are encouraged to anticipate the challenges students may encounter in the lesson and to be prepared with appropriate strategies to assist them (Kazemi *et al*., 2007).

After the planning phase, a teacher conducts the study lesson based on the plan. This lesson plan is usually duplicated and distributed to each observer. The number of colleagues who observe the lesson varies, depending on the purpose of the particular lesson study. If it is a lesson study by a subject group or a grade level of teachers, the number of teacher observers is usually smaller. On the other hand, when the lesson study is carried out in a large public research meeting, dozens of observers (including curriculum experts and tertiary teachers) will attend (Fernandez & Yoshida, 2004). In each case, the observers will carefully watch what the teacher and the students do. The observers listen attentively to all contributions made by the students and make notes on the lesson plan of the critical remarks by or behaviours of the teacher and the students in relation to achieving the lesson outcomes. The observation notes on a lesson plan serve as references for later discussion in a post-lesson conference or forum. In most cases, the post-lesson forum follows immediately after the lesson. If time or schedules do not allow for it, the post-lesson forum may take place later on the same day.

During the forum, the teacher briefly explains the intended outcomes of the lesson and the points emphasised in the lesson plan. All observers are encouraged to contribute to refining and improving the lesson by asking for clarification, acknowledging the strengths and identifying the challenges. Comments on the challenges should be accompanied by suggestions and alternatives.

In summary, lesson study is a professional development activity that is characterised as classroom-situated, context-based, student-focused, improvement-oriented and teacher-owned. It is also collaborative (Ono, 2008*)*. These features of lesson study match the elements or principles that professional development requires (Webster-Wright, 2009). Study

groups, peer coaching and demonstration lessons are effective strategies in professional development (ASCD, 2010; Loucks-Horsley et al, 2010) for scientific enquiry.

It is worth noting that lesson study has been practised in Japan for so long that it is taken for granted by Japanese teachers and administrators (Hashimoto, Tsubota & Ikeda, 2003); and generally speaking, Japanese teachers have plenty of opportunities to observe lessons facilitated by others (Fernandez *et al*., 2004; Lewis, Perry & O'Connell, 2006). As a result, the experience of lesson study in Japan has the potential to establish an effective teacher professional development programme in schools (Lewis *et al*., 2006).

2.2.2.2 Instructional culture in schools

Mathematics teachers and the school management team do not work alone with a group of students in their classrooms. Rather, they work with other teachers and professionals collectively within a big organisation, namely the school, in the interest of effective teaching and meaningful learning of mathematics. Most of the human, financial and material resources available for instruction are made available by schools. The school is also the physical and social context within which teachers and students routinely interact. In the opinion of Stronge (2007), most teachers view teaching and learning as a reciprocal process and an equal partnership, in which teachers, the school management team and students all shape the environment and support the learning endeavour through their thoughts and behaviours.

Each school has its own social structure and tends to organise instruction according to prevailing local conditions. This is often called the organisational culture (or instructional culture) of a school (Newman *et al.*, 2000). The organisational culture of a school is defined by the "nature and content of the professional community", "collaborations" among staff members, "collective and shared goals" for TLM and "opportunities for students and staff to exert influence" on the teaching and learning at their school (Newman *et al.*, 2000:33).

2.2.2.3 Instructional programmes

In many instances, schools differ based on the "quality and coherence of their instructional programmes" (Heck, 2007). Although all the secondary schools in Vhembe District in the Limpopo Province of South Africa follow the same basic set of curriculum guidelines for designing and developing learning programmes for mathematics, implementation of these guidelines differs from school to school. Implementation depends on many factors, such as:

students' prior knowledge; availability of learning support materials; collaboration with teachers of other subjects in teaching parallel material; and other pertinent factors. These have been characterised as the instructional programme of the school. In other words, the instructional programme has been defined as coordination and focus around clear and specific learning goals by mathematics teachers within a school. To the extent that there is a clear, specific and coherent instructional programme for mathematics at a school, it is likely that the capacity of the school will be boosted in this regard.

2.2.2.4 Instructional leadership at the school

It is increasingly recognised that managing teaching and learning is one of the most important activities for principals (if not the most important), departmental heads and other school leaders (Bush & Glover, 2009). Thus, the core purpose of a principal is to provide leadership and management in all areas of the school, to enable the creation and support of conditions under which quality teaching and learning takes place and which promote the highest possible standard of student achievement (Bush & Glover, 2009).

The international literature refers mainly to "leadership" of teaching and learning, or "instructional leadership" (e.g. Leithwood, Day, Sammons, Harris & Hopkins, 2006); but the term "management" is widely used in South Africa (Bush *et al.*, 2008). The concepts of management and leadership are often used interchangeably – management and leadership are the major functions of the school principal (Bush, 2003). It is therefore important to briefly distinguish between management and leadership. These two concepts are at once separate and intertwined on a functional level (Bush, 2003). While leadership and management share considerable similarities, it may be useful to discuss the focus of each concept. According to Robinson (2007:21), management is mainly concerned with:

- keeping the organisation running;
- maintaining day-to-day functions;
- ensuring that the work gets done;
- monitoring outcomes and results; and
- organising efficiency.

Leadership, on the other hand, is more specifically concerned with:

- personal and interpersonal behaviour;

- focus on the future;
- vision and purpose;
- change and development;
- the quality of outcomes;
- achievement and success; and
- personal effectiveness.

According to Bush (2003), principals cannot be effective leaders without performing managerial functions. On the other hand, principals cannot push aside their leadership activities while performing as managers. One can, therefore, think of leadership as being tied up with management in a complex knot. Such a knot is a complex thread comprising need to manage people, time and instruction, while at the same time infusing a school with passion, purpose and meaning (Bush, 2003).

Leithwood *et al.* (2006) claim that leadership accounts for about 5 -7% of the differences in student achievement across schools. Principals can also impact on classroom teaching by adopting a proactive approach and becoming "instructional" leaders. There is not a single documented case of a school successfully turning around its student achievement trajectory in the absence of talented leadership (Leithwood *et al.*, 2006:5). Robinson (2007:21) stresses that the impact on student outcomes is likely to be greater where there is direct leader involvement in the oversight of, and participation in, curriculum planning and coordination and teacher learning and professional development. The closer leaders are to the core business of teaching and learning, the more likely they are to make a difference to students' achievement levels (Robinson, 2007:21).

The idea that schools should coordinate instruction internally – to ensure that student opportunities to learn are coherent within and across grade levels – seems unusual in school practice: few schools seem to have the means of establishing or sustaining such coordination. In addition, few principals enact their role as that of an instructional leader; though many now claim such a role, in practice few know how to do such work and most leave such matters to the discretion of individual teachers (Bush *et al*., 2009). With a tremendous increase in participation management, resulting from new legislation and changed education policies (such as the rights of teachers to strike or engage in industrial action) principals now face new challenges and problems. Botha (2002:358) distinguishes between problems and challenges:

"problems imply something is wrong with us, whereas challenges infer something we have to stretch to acquire."

To the principal, responding to challenges and problems implies the ability to relate the past to the present with a projection into the future. The basic issue is determining at which point leadership should be exercised in schools to ensure both their existence and organisational survival (requiring social control) and organisational progress (requiring individual or group development). In other words, the essential questions to ask are: what is the nature and degree of social control needed for the school's survival? What is the nature and degree of individual or group development needed for the school's progress (Botha, 2002:358)? Thus, it is required that the school principal is capable of responding to challenges and problems that hinder progress or development at the school.

Generally speaking, the principal is confronted with challenges such as:

- creating a culture of teaching and learning;
- having knowledge of current education legislation;
- formulating and developing a mission, goals and objectives;
- introducing the NCS; and
- integrating technology into the school structure.

According to Botha (2002:358), the effective principal is able to transform these challenges into potential opportunities.

As Hoadley (2007:1) states, in the South African context, "there is a consensus around the importance of leadership to improve student outcomes". Bush and Heystek (2006) show that South African principals are mainly concerned with financial management, human resource management and policy issues. The "management of teaching and learning" was ranked only seventh out of 10 leadership activities in a survey of more than 500 Gauteng principals (Bush *et al.*, 2006:68). Chisholm, Hoadley and Kivilu (2005) add that principals' time is largely consumed by administrative activities.

Bush and Glover (2009:19) (referring to the South African context) claim that a principal with a strong focus on managing teaching and learning would undertake the following activities:

- Oversee the curriculum across the school.

- Ensure that lessons take place.
- Evaluate student performance through scrutiny of examination results and internal assessments.
- Monitor the work of HoDs through scrutiny of their work plans and portfolios.
- Ensure that HoDs monitor the work of teachers within their learning areas.
- Arrange a programme of class visits followed up by feedback to teachers.

Bush and Glover (2009:19) point out that even a combination of well-planned objectives, strong organisation, capable direction and motivation has little probability of success unless an "adequate system of control" is in place. Control in a school is the "principal's means of checking whether the work is done". Bush and Glover (2009) go on to say that it is a systematic attempt to set appropriate standards for the objectives of the school, to observe the actual achievements and to compare them with standards, to accomplish the mission and objectives and to take corrective measures to ensure that all the resources of the school are used as effectively as possible. As instructional leaders, principals give greater attention to working with teachers to coordinate the school's instructional programme, solving instructional problems collaboratively, helping teachers secure resources and creating opportunities for in-service and staff development (Bush & Glover, 2009).

According to Bush and Glover (2009), controlling teachers' work would entail that the principal evaluates teachers' work in the following ways:

- Class visits are a valuable tool for the principal to improve instruction. Class visits should be of a clinical, and not an autocratic, nature. They should not be a fault-finding exercise or an inspection. Clinical supervision encourages the principal to support and work in collaboration with the teacher to identify instructional problems, determine the cause of problems, and work together towards finding a solution. The HoDs should share the responsibility of controlling the teacher's planned work. Students' written work should also be checked by the principal and the HoDs.
- Principals should ensure the availability of appropriate learning and teaching support materials (LTSM).

The importance of leadership in shaping the school's ability to offer quality instruction cannot be over-emphasised. The most dominant strand of instructional leadership studies begins from the premise that principals constitute one of the key drivers of what occurs in

each classroom across the school. Danita (2006), for example, observes that research on school effectiveness concluded that strong administrative or principal leadership is one of the "within-school" factors that make a difference in student achievement. More recently, Dhlamini (2008) found that principals have a lot to learn about: how and under what conditions new instructional methods work in classrooms; how to support teachers as they develop new instructional skills; and how to integrate a commitment to quality instruction within the demands of high-stakes testing.

In South Africa, only a handful of small-scale studies (for example: Dhlamini, 2008; Mamabolo, 2002) have explored the role of principals as instructional leaders, but none of these studies have focused on mathematics specifically. The failure to account for other leadership influences on mathematics teachers, emanating from both inside and outside schools, is a serious omission in the research on school effectiveness and quality. Thus analysis of capacity in this study considers leadership as a key component of a school's inventory for quality instruction in mathematics.

2.2.2.5 The quality and quantity of technical or material resources

The quality and quantity of materials or physical resources available for teaching and learning is also critical in the framework of instructional capacity. Resources such as staffing levels, instruction time, class size, manipulatives and other (scientific) equipment are critical material resources that impact on the teaching of mathematics at a school (Heck, 2007). This approach of focusing on the resources for instruction and the related interactions is informed by the work of Cohen and Ball (1999:3), whose framework provides the necessary links between capacity and classroom instruction.

The central argument in Cohen and Ball (1999) is that instruction begins with and involves interactions among three components or instructional units: the teacher, students and materials (both physical and intellectual materials). In this view, each of the three elements is essential, but instruction requires all three. "If instruction requires all three components, then instructional capacity – the capacity to produce worthwhile and substantial learning – must also be a function of the interactions among three elements, not the sole province of any single one, such as teachers' knowledge and skill, or the curriculum" (Cohen & Ball, 1999:3).

By focusing on the interactions among the three components of an instructional unit, Cohen and Ball (1999) bring to the fore an important dimension of instructional capacity, viz. the

social dimension. In other words, the capacity to deliver quality instruction depends not only on the individual teacher's intellectual and personal resources, but also on interaction with, among others, specific groups of students, colleagues at school, subject area committees, the curriculum and materials developed by others, and the "broader social norms and conventions at the school and in the society" (Cohen & Ball, 1999:3) concerning teaching and learning.

Teachers' intellectual and personal resources influence instructional interactions by shaping how teachers apprehend, interpret and respond to materials and students (Heck, 2007). There is considerable evidence that teachers vary in their ability to notice, interpret and adapt to differences among students (Heck, 2007). Important teacher resources in this connection include their conception of knowledge, understanding of content and flexibility of understanding; acquaintance with students' knowledge and ability to relate to, interact with, and learn about students; and their repertoire of means to represent and extend knowledge, and to establish classroom environments (Heck, 2007). All these resources mediate how teachers shape instruction. Consequently, teachers' opportunities to develop and extend their knowledge and capabilities can affect instruction considerably by affecting how well teachers make use of students and materials (Heck, 2007).

The resources that students bring influence what teachers can accomplish. Students bring experience, prior knowledge and habit of mind; these influence how they apprehend, interpret and respond to materials and teachers. Students – and interactions among students – shape the resources for their own learning (Heck, 2007). By materials, Heck (2007) means what students are engaged in, as presented in texts and other media, as well as in problems, tasks and questions posed to students. Instructional materials can mediate students' engagement with the content to be learned, though sometimes the materials themselves are what is to be learned (Heck, 2007). The instructional materials can be thought of as the material (as opposed to social) technologies of instruction, including print, video and computer-based multimedia (Warwick, Hennessy & Mercer, 2010). Curriculum is often developed in advance, but student and teacher interactions with this material comprise the enacted – which is to say, the actual or effective – curriculum.

These material technologies influence instructional capacity by constraining or enabling students' and teachers' opportunities to learn and teach (Warwick, Hennessy & Mercer, 2011). Features of these technologies that seem likely to affect instructional capacity are their complexity and the design of teachers' and students' intended engagement (Warwick *et al*.,

2011). In the case of mathematics materials, we would expect that the nature of the problems offered, the development of the ideas, the number and variety of representations, and the ways in which multiple representations were coordinated, would shape what teachers and students could do and learn (Christou, Eliophotou-Menon & Philippou, 2009).

Instructional capacity is partly a function of what teachers know students are capable of doing and what teachers know they are capable (professionally) of doing with students. This means that every student and curriculum is a bundle of possibilities and that teachers whose perceptions have been more finely honed to see those possibilities, and who know more about how to take advantage of them, will be more effective (Hunzicker, 2011). It follows from this analysis that any given element of instruction shapes instructional capacity by the way it interacts with and influences the other elements. If this last point is roughly right, then capacity is not a fixed attribute of interactions. This means that speaking in terms of what teachers or students "bring" to interactions may be misleading, since what students and teachers bring may be used to better or worse advantage by others. In discussing what students bring to a task, it is important to recognize that it depends in part on what teachers can see and use in students (Christou *et al*., 2009). One reason that different teachers elicit different responses and work from the same students is that what teachers know, believe and can do shapes: their perceptions of what students bring; the opportunities they subsequently extend to students; and their interpretation of students' ensuing work (Tunks & Weller, 2009).

Similarly, materials both depend on their use by students and teachers and affect such use. But here we can see teachers' unique position in the construction of instructional capacity (Remillard, 2009). Teachers' knowledge, experience and skills affect interactions of students and materials in ways that neither students nor materials can. This is because teachers mediate instruction: their interpretation of educational materials affects curriculum potential and use, and their understanding of students affects students' opportunities to learn (Remillard, 2009). As teachers learn new things about content and students, they notice different things about both, and are able to use them differently. Change in students, teachers, or materials has the potential to change the relations of teachers, students and materials - and hence affect instructional capacity. But change in teachers has unique potential, because teachers mediate all relationships within instruction (Remillard, 2009). If instructional capacity is a property of interactions among teacher, students and materials, then

interventions are likely to be more effective if they target more interactions among more elements of instruction, rather than focusing on one element in isolation from others. Interventions that focus, not only on aspects of particular elements, but also on their relations, are more likely to improve capacity (Penuel, Fishman, Yamaguchi & Gallagher, 2007).

Framed in this manner, and focusing on the five dimensions discussed earlier on, instructional capacity becomes a useful concept for investigating the construction of quality instruction because of the way it draws attention both to the classroom and the school-wide effects.

To date, however, there appears to be little empirical work that seeks to understand school quality and its improvement using instructional capacity as developed in this framework. Therefore, for researchers in developing countries (such as Zimbabwe, Mozambique and South Africa), a realisation of capacity that explores its "multi-dimensionality" and the fact that it is "dynamic" (and varies with time, locality, participants, etc.), should make it attractive, because of the large variations in contexts and processes of schooling (relative to what is often found in developed countries).

2.3 AN OVERVIEW OF THE NCS

The adoption of the Constitution of the Republic of South Africa (Act 108 of 1996) provided a basis for curriculum transformation and development in South Africa. The preamble states that the aims of the Constitution are to:

- heal the divisions of the past and establish a society based on democratic values, social justice and fundamental human rights;
- improve the quality of life of all citizens and free the potential of each person;
- lay the foundations for a democratic and open society in which government is based on the will of the people and every citizen is equally protected by law; and
- build a united and democratic South Africa able to take its rightful place as a sovereign state in the family of nations.

The NCS lays a foundation for the achievement of these goals by stipulating learning outcomes (LOs) and ASs, and by spelling out the key principles and values that underpin the curriculum. One of the key principles that underpins the NCS (and even CAPS - see Section 1.1) is OBE and a discussion of this principle follows.

2.3.1 Outcomes-based education

> Outcomes-based education means clearly focusing and organising everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences. This means starting with a clear picture of what is important for students to be able to do, then organising curriculum, instruction, and assessment to make sure this learning ultimately happens (Spady, 1996:1).

OBE has been selected as the most likely "educational methodology" to equip students for life in the South African democracy. It strives to enable all students to reach their maximum learning potential by setting the Learning Outcomes to be achieved by the end of the education process (Spady, 1996).

It should be evident from the discussions to follow that OBE is portrayed as an educational model with great potential for the improvement of education in South Africa. Therefore, the learning theory considered to be relevant to this study is discussed here. With respect to OBE, the rationale for choosing it as an alternative to Christian National Education (CNE) for South Africa is briefly examined. The essence of OBE and what it entails is discussed, including its underlying philosophy, namely social constructivism.

2.3.1.1 Rationale for choosing OBE to renew education in South Africa

OBE, to a large extent underpinned by constructivism, was introduced as a "new" educational philosophy in 1996 in an attempt to rid the South African education system of the disparity and lack of equity that prevailed during the apartheid years. The general consensus in the post-apartheid government and wider public was that CNE did not adequately address the needs of all South Africans, especially those who had been disadvantaged by what was then referred to as "gutter education". Students who completed 12 years of CNE were generally unskilled and not trained to be absorbed directly into the workforce. Botha (2002:365) provides some support for this view in his argument that research "has consistently shown that South African students lack substantial problem-solving and creative abilities".

CNE was strongly underpinned by behaviourist learning theories and overwhelmingly characterised by the transmission of knowledge from the teacher to (mostly) passive students. Differentiation with regard to the diversity and different learning needs of students was limited, at best, in CNE. A different educational philosophy and system was necessary, not only to address the needs of all students in the country and bring about greater equity, but also to take account of what was happening globally. As Botha (2002:361-362) argues:

"educational change was required to provide equity in terms of educational provision and to promote a more balanced view of South African society"; and "OBE as a model was chosen as the most likely to address the crisis in South African education".

Malan (2000:22) claims that "Outcomes-based education is currently favoured internationally to promote educational renewal and has been implemented in countries such as Canada, the United States and New Zealand". Spady (1996) maintains the following:

> [T]he OBE efforts of today are a direct response to the many demands for change of what some call our outdated "Industrial Age system" of educating children in an era of high technology, global communications, and rapidly expanding information systems. These changes involve fundamentally refocusing and redirecting our education system from an emphasis on means to an emphasis on ends, from procedures to purposes, from time spent to outcomes accomplished, from roles of personnel to goals for students, from teaching to learning, from programs to performance, from curriculum to results, and from courses taken to criteria met. (Spady, 1996:1)

These ideas coincide with reasons put forward by the democratically elected post-apartheid government to completely change the education system and choose OBE as the most appropriate model to counter the past wrongs in South African education.

Since the research occurred within an OBE context, it is essential that the salient features of the approach and the impact of these features on this research are described and analysed. One such feature is constructivism.

2.3.1.2 Constructivism

Matthews (2000:161) contends that "constructivism is undoubtedly a major influence in contemporary science and mathematics education". In essence, constructivism is described as a learning theory that claims that: "knowledge is not passively received, but is actively built up by the cognising subject"; and "that the function of cognition is adaptive and serves the organisation of the experimental world" (Matthews, 2000:175). Carr, Jonassen, Litzinger and Marra (1998:5) also mention the fact that constructivism emphasises student activity and how students construct knowledge as a process of making sense and giving meaning.

Three prominent theorists in this field are: Von Glaserfeld, a radical constructivist; Piaget, who focuses on the "cognising person"; and Vygotsky, who emphasises the importance of "social interaction" in learning (Sfard, 1998:489). Atherton's (2003:1) explanation of what constructivism entails emphasises the roles of the social and communicative dimensions of

learning. Constructivism is viewed as an alternative learning theory to behaviourism; and according to Atherton (2003:1); it fits in "somewhere between the cognitive and humanistic views". This emphasis on the social aspect points towards a more active role by the student "in a joint enterprise with the teacher of creating new meanings" and ties in well with Vygotsky's view on the importance of "interpersonal exchange" in the learning process (Sfard, 1998:489). A distinction is thus made between: cognitive constructivism, which deals with understanding and making sense; and social constructivism, which emphasises "how meanings and understandings grow out of social encounters" (Atherton, 2003:1). It should, therefore, be noted that oral communication, which includes feedback, plays a major role in making social encounters into learning events that facilitate sense-making and understanding.

The role of communication within constructivism is aptly described by Atherton (2003:1) as that which allows "conversational theories of learning to fit into the constructivist framework". The student's active mental involvement is reflected in the teacher's deliberate effort "to enter into a dialogue with the students, trying to understand the meaning of the material to be learned by that student". Carr *et al.* (1998:5) similarly argue that constructivism emphasises the need for "learning to support collaboration", allowing students to "talk to one another about their learning". What is important during this process of collaboration and sharing of information is that students are compelled to "crystallise what may be internally fuzzy into concrete words, and encourages knowledge synthesis and meaning making" (Carr *et al.*, 1998:8). This resonates with the work of numerous researchers and academics (for example, Mercer & Hodgkinson, 2008; Alexander, 2002) who emphasise the central importance of classroom talk in promoting learning. Indeed, Mercer and Hodgkinson (2008) see talk as the most important educational tool for guiding the development of understanding and for jointly constructing knowledge. Thus, dialogic teaching is seen as being: collective, supportive and reciprocal, through the sharing of ideas and alternative viewpoints; and cumulative, in group-based and whole-class situations (Mercer & Hodgkinson, 2008).The characteristics of facilitative learning theory and the strategies to enhance learning and increase students' independence show remarkable similarities with constructivism, hence its discussion below.

2.3.1.3 Facilitation theory (as a humanist approach)

Carl Rogers is generally viewed as the person who developed facilitative learning theory (Dunn, 2002:1). According to Dunn (2002:1), this theory is based on the premise "that

learning will occur by the teacher acting as a facilitator, that is, by establishing an atmosphere in which students feel comfortable to consider new ideas and are not threatened by external factors". Watkins (2005:135) makes a similar point when he says that "facilitative teaching involves creating the conditions under which learning can occur without seeking to control the outcome." Smith and Higgins (2006:491) add the importance of using students' contributions: "Good teaching is generally seen as the ability to set a certain emotional climate, to use students' experiences as educational resources, to provide plenty of evaluative information to students, and to encourage collaboration and participation."

The following characteristics of facilitative teachers and the strategies to enhance learning and increase independence in students show remarkable similarities with constructivism. Watkins (2005:135) emphasises the facilitative teacher's awareness of the students' "capacities, needs and past experience" and the ability to use this information to "create a learning situation in which the students can meet their needs or solve a problem in an autonomous and independent way". According to Smith and Higgins (2006:491), facilitative teachers: are "less protective of their own constructs and beliefs"; they show a tendency to be able to listen to students more often, especially to their feelings; they are "inclined to pay as much attention to their relationship with students as to the content of the course"; and they "are apt to accept feedback, both positive and negative and to use it as constructive insight into themselves and their behaviour". Similarly, Mitchell (2010:4) mentions the following principles of effective practice in facilitating learning: participation on a voluntary basis, respect for the other person's self-worth and collaboration between students and the facilitator engaged in a cooperative enterprise. Within this kind of teaching practice, students are treated significantly differently to the way they are treated in the conventional authoritative classrooms, as: they "are encouraged to increasingly take responsibility for their own learning"; they are allowed to "provide much of the input for the learning that occurs through their insights and experiences"; and they "are encouraged to consider that the most valuable evaluation is self-evaluation and that learning needs to focus on factors that contribute to solving significant problems or achieving significant results" (Mitchell, 2010:4).

2.4 CONCLUSION

In this chapter, the five key dimensions of instructional capacity, which constitute the framework of this study, were outlined (Section 2.2.2). In essence, these dimensions define tools available and mobilised by a school to offer quality instruction in a subject area. The

ability to offer quality instruction, therefore, depends on the construction and organisation of such tools and their use by various school participants (parents, principals, subject advisors, teachers, and students), their maintenance or replenishment.

Since OBE is the philosophy that underlies South Africa's current education system, its salient feature - constructivism - was elaborated on. Constructivism emphasises the need for learning to support collaboration, allowing students to talk to one another about their learning. For this to happen, teachers need to be aware of students' capacities, needs and past experiences and must be able to use this information to create a learning situation in which students can solve a problem in an autonomous and independent way.

It also emerged in the literature review that teachers always have self-oriented, task-oriented and impact-oriented concerns as they are introduced to and take on new programs, practices or process. These concerns can guide the selection of strategies for professional development and provide insight into the content of the strategies in order to adequately address their concerns as they go through the change process. Since each school has its own social structures and tends to organise instruction according to prevailing local conditions, a professional development activity that is characterised as classroom-situated, context-based, student-focused, improvement-oriented and teacher owned is often considered effective.

It was also evident from literature that, in many instance, schools differ in student achievement level based on the quality and coherence of their instructional programmes that ensure students' opportunities to learn are coherent within and across grade levels. Also it was clear from literature that material resources such as staffing levels, teacher knowledge, instructional time, class size, print, video, and computer-based multimedia also mediate how teachers shape instruction. Therefore, leadership and management in all areas of the school should be provided to enable the creation and support of conditions under which quality teaching and learning takes place. The next chapter concerns the methodology employed in the study.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this thesis, it was argued that, among others, the ability to offer quality instruction in mathematics is determined not only by the presence of particular resources, but also by the various school participants (parents, principals, subject advisors, teachers and students), the construction and organisation of such resources and their maintenance or replenishment. The study therefore seeks to establish "instructional capacity" as a phenomenon that allows schools to offer quality instruction in TLM.

Since people act according to the meaning they attribute to the objects and persons around them, their reality is socially constructed (Krathwohl, 2004). From this viewpoint, it was necessary to see the school's instructional capacity through the eyes of the actors in order to establish the purpose of people's behaviour. Therefore "instructional capacity" was examined in a number of bounded units, including: teachers and teaching; students and learning; curriculum and physical resources; and organisational leadership and institutional culture. The study comprises a descriptive survey design.

3.2 A QUALITATIVE RESEARCH APPROACH

3.2.1 A brief overview

The term "qualitative" denotes, not only a technique of gathering and analysing descriptions of a phenomenon, but also a point of view about an individual's perceived reality (Krathwohl, 2004). The approach was chosen because it allows one to understand the situation better, as understood by the research participants. In fact, contextualising the phenomenon was of great importance. Focusing on the selected high and low achieving secondary schools in the Vhembe District in Limpopo Province of South Africa, the study sought to investigate how schools, as units, constructed and made sense of their roles as implementers of the new curriculum. Moreover, the study investigated what practices they then generate out of these interpretations to result in a particular configuration of capacities. The study went further by acknowledging that observed practices were not only a function of the individuals involved, but were also shaped by the material conditions, especially the structures and cultures of the organisations within which they found themselves. Therefore the descriptive survey

employing qualitative research techniques was part of the interactive research aimed at obtaining an in-depth understanding of the individual, group or event (Krathwohl, 2004). Krathwohl elucidates the concept further by describing some of the essential characteristics. He asserts, among other things, that:

- Qualitative research seeks understanding and employs qualitative methods, such as in-depth interviewing and observations.
- Qualitative methods are humanistic. The methods by which people are studied affect how they are viewed. When people's words and acts are reduced to statistical equations, we lose the human side of social life.
- In qualitative research, the researcher has the natural settings as the direct source of data and the researcher is the key instrument. The researcher looks at the setting and people holistically. The people being studied are not reduced to variables, but are viewed as a whole. In contrast to a natural science approach, the qualitative researcher strives for understanding, on a personal level, of the motives and beliefs behind people's actions.
- Qualitative research is descriptive and the data can be in verbal form rather than numeric form. The written results of research contain quotations from the data to illustrate and substantiate the findings.
- Meaning is of essential concern for qualitative research. Researchers who use this approach are interested in the way different people make sense of their lives.
- The task of the qualitative researcher is to describe the meanings shared with the participants, which may, in turn, make it possible to explain why people behave as they do.

In light of the characteristics listed above, it is clear that the aims of this study can be achieved through qualitative research. Kwinda (2002:30) corroborates this notion in stating that the qualitative method is useful when focusing on teachers teaching, principals managing and leading schools and on classroom activities and school interaction.

Furthermore, using a descriptive survey design allowed for the exploration of the phenomenon in a number of systems and sub-systems, where the common characteristics and the differences came to the fore. No assumptions were made about the similarities or differences in the construction and development of instructional capacity within the entities that were studied. In fact, this investigation was conducted precisely to establish the

commonalities and unique features of instructional capacity, as it was constructed and practised in a variety of settings and organisations within Malamulele Circuit schools in the Vhembe District in Limpopo Province.

3.2.2 Site selection and sampling

Site selection and sampling processes are used to identify cases that the researcher is going to study (Budhal, 2000:59).

3.2.2.1 Site selection

According to McMillan and Schumacher (1993:411), to obtain freedom of access to a site that is suitable for the research problems and accessible to the researcher in terms of time, mobility, skills and resources is a negotiating process. The researcher usually obtains information regarding the site in advance: its potential suitability, general history, routines and social system. In the study, ten public secondary schools in the Vhembe District in the Limpopo Province of South Africa were chosen on the basis of how typical they were. That is to say, socio-economic status, educational attainment based on the achievement levels of Grade 12 students in mathematics in the 2008-9 matriculation examinations, ethnic composition, location and accessibility were looked into. All ten schools were established prior to the 1994 democratic elections in South Africa and were viewed as rich sources of information because they could be said to belong to what is normally referred to as "previously disadvantaged schools". The criteria employed to select the 10 schools hinged on the quality of instruction in mathematics, as measured by the pass rate in the Mathematics matriculation examinations of 2008 and 2009. How instruction relates to pass rate is briefly explained in Section 4.2.1.3. Purposeful sampling was used to choose the participants.

3.2.2.2 Purposeful sampling

Purposeful sampling, according to McMillan and Schumacher (1993:413), involves choosing samples based on the likelihood that they are knowledgeable and informative regarding a particular phenomenon. A number of purposeful sampling strategies can be identified. These include site selection, comprehensive sampling, maximum variation sampling, network sampling and sampling by case type. The latter was employed in the present study. In sampling by case type, concept-based sampling is an example that involves selecting information-rich people or situations known to experience the concept under investigation

(McMillan & Schumacher, 1993). This means that prior information is used to decide on samples as well as in site selection (McMillan & Schumacher, 1993). The criteria that were considered in choosing the sample were informed by the research problem, the major data collection strategy and the availability of information-rich cases.

Therefore, the target population for the study included: FET band mathematics students who provided the primary data for the study; practising secondary school mathematics teachers; principals; and mathematics curriculum advisors whose views on the construction of a school's instructional capacity in mathematics was valuable to the study.

From ten secondary schools that met the criteria for participation in the study, a purposively selected sample consisted of: 40 Grade 12 mathematics students (4 students at each school); ten principals; ten Grade 12 mathematics teachers; and five mathematics curriculum advisors (three from the circuits and two from the district). At each of the ten schools, the principal and the Grade 12 teacher were interviewed and a focus group discussion with four students was conducted. The criteria used to recruit the focus group participants were fluency in English and gender (an equal number of boys and girls). The sample size, including mathematics curriculum advisors, was $(6 \times 10) + 5 = 65$. One main limitation of this kind of sampling is that some categories of people might be over-represented in certain situations (Fink, 1995), as can possibly be seen in Table 3.1, which shows the composition of interviewees.

Table 3.1: Composition of interviewees

	Gender		
Respondent	**Male**	**Female**	**Total**
Advisors	4	1	5
Principals	8	2	10
Teachers	6	4	10
Students	20	20	40
Total	38	27	65

3.3 INSTRUMENTS

3.3.1 Document analysis

Documents are seen as a representation and reflection of reality (Krathwohl, 2004). According to McMillan and Schumacher (1993:433), this is a non-interactive strategy, with

little or no reciprocity between the researcher and participants. McMillan and Schumacher (1993) define artefacts as tangible manifestations of the beliefs and behaviours that form a culture and describe people's experience, knowledge, actions and values. Artefacts in educational institutions may take the form of personal documents, official documents and objects.

Since the study sought to produce descriptions of the practices that exemplified the unique organisation of resources and materials at each school, document analysis protocol was essential. For purposes of this study, after consultation with experts in mathematics education, those official documents that were chosen have a direct bearing on TLM. The questions that guided selection of the official documents that were scrutinised at each school were: What are the principal's means of checking whether or not work is done?; Is there a clear, specific and coherent instructional programme for mathematics?; What are the materials or physical resources available for TLM? These questions necessitated scrutiny of the following official documents at each school:

- The school's vision and mission statement
- Policy documents
- Minutes of staff and departmental meetings
- Mathematics learning programme for senior and FET phases
- Mathematics work schedules for senior and FET phases
- School annual assessment programme
- Registers
- Timetables

This was done to establish the principal's means of checking whether or not work is done, coherence of instructional programmes in mathematics, availability of materials or physical resources for TLM and compliance of timetable with the NCS policy on the number of periods for mathematics per week and per grade level.

3.3.2 Observation (passive participation)

McMillan and Schumacher (1993:420) define participant-observation as "an active process which includes muted cues (facial expressions, gestures, tone of voice and other unverbalised social interactions which suggest the meanings of language)". According to Budhal

(2000:56), the process entails a researcher engaging in a careful, systematic experiencing and conscious recording of details regarding many aspects of a situation. Budhal (2000:56) enumerates the activities undertaken by the researcher, as a participant observer, as noting how people perceive reality, their words, feelings and beliefs. Krathwohl (2004) goes further to claim that observers are judged by whether or not they are sensitive enough to capture the critical aspects of what is occurring, by how well they can make sense of these aspects and by how accurately their observations fit the data. The assumption is that an understanding of the inner perspective of principals, teachers, curriculum advisors and students can only be achieved by participating in their world and gaining as much insight as possible. According to Budhal (2000:63), there are five types of participant observation, namely:

- *External participation*, which constitutes the lowest degree of involvement in observation. This type of observation can be done by observing situations on television or videotape.
- *Passive participation*, which means the researcher is present at the scene of action, but does not interact or participate. The researcher finds an observation post and assumes the role of a bystander or spectator.
- *Balanced participation*, which means that the researcher maintains a balance between being an insider and being an outsider. The researcher observes and participates in some activities, but does not participate fully in all activities.
- *Active participation*, which means that the researcher generally does what others in the setting do. While beginning with observation in order to learn the rules, as these are learned the researcher becomes actively engaged in the activities of the setting.
- *Total participation*, which means the researcher is a natural participant. This is the highest level of involvement and usually comes about when the researcher studies something in which he or she is already a natural participant.

Therefore, the main reason for using participant observation is that "self-report measures", such as questionnaires and interviews, are often inadequate for dealing with activities and behaviours that participants may themselves be unaware of, or which they are unable to verbalise (Krathwohl, 2004). However, Krathwohl (2004) asserts that a central problem of observation is that individuals who are conscious of being under scrutiny are likely to behave differently from usual, often in the direction of what they perceive to be more socially acceptable behaviour or in accord with the observer's expectations. Indeed, sometimes it is

hard to predict how individuals will react to observation, but usually they do react in one way or another (Krathwohl, 2004). Therefore, a more common solution is to use passive participation by the observer to reduce obtrusiveness (Krathwohl, 2004).

For purposes of this study, investigation of capacity within mathematics classrooms was important. Therefore, classroom observation focused on the interaction between the teacher, students and materials. This was done to collect data on:

- resources contributed by the teachers (such as teachers' knowledge and skills and attitude to content, students and innovation in general),
- students' engagement with teaching and learning and the use of physical materials (such as textbooks, material technologies including print, video and computer-based multimedia, manipulatives and facilities available for learning) and,
- the nature of intellectual tasks and problems and the discourses through which content is presented in a particular mathematics classroom.

So to capture what happens in the mathematics classrooms and at the same time reduce obtrusiveness, passive observation was considered appropriate for the study. An observation inventory was developed by adapting Gagné & Briggs's (1974) assumption on designing instruction that involves *analysing requirements*, *selecting media* and *designing the instructional events*. This assumption relates to the general instructional events that are intended to describe the activities of the teacher in a conventional learning environment, namely:

- ensure reception of coming instruction by giving students a stimulus;
- tell students what they will be able to do as a result of instruction;
- ask for recall of existing relevant knowledge;
- present stimulus materials (content);
- provide student guidance;
- ask the student to respond, demonstrating learning;
- give informative feedback on student's performance;
- assess performance;
- provide varied practice to generalise the capability.

The observation inventory comprises the following main components:

- Lesson prerequisite
- Reform-oriented practices
- Lesson management
- Lesson conclusion
- Classroom management
- Overall impression

Observations and interviews interact – observations provide new meanings to the interviews, and interviews suggest new things to look at or attach new meanings to the observations (Krathwohl, 2004). Supporting this view, mere observation without collecting information from the participants themselves becomes futile and, therefore, data collection by means of interviews is also necessary.

3.3.3 Interviews

Krathwohl (2004) asserts that wherever there is a desire to tap an internal process, to gain knowledge of a person's perceptions, feelings, or emotions, or to study a complex individual or social behaviour, some form of interviewing is most helpful, i.e., it is the major means of tapping thought processes. The structure of the interviews that were employed in the research came closer to that of an everyday conversation, but for purposes of research, the interview involved a specific approach, called a semi-structured approach. The semi-structured interview was conducted according to a loosely structured guide that focused on certain themes that covered questions formulated in the research problem. The interviews were tape-recorded openly, with the permission of the interviewee, for subsequent interpretation.

Denzin and Lincoln (1998) relate early use of the term "interview" to meetings, particularly conversations, of a ceremonial nature. Authors such as Creswell (1994) also support the idea of interviews as a form of conversation. Interviews reflect a broader historical and cultural questioning of social realities (Creswell, 1994). When emphasising the significance of interviews in education as a human science, Rubin and Babbie (2008:285) contend that:

> Access to the human realm is gained through its expression. The principal form of expression is linguistic although facial expressions and bodily gestures, including dancing, are also sources. But the richest form of information is linguistic expression.

The goal of interviews was to establish the specific circumstances and conditions under which principals and teachers worked and to obtain descriptions in order to have relevant and

precise material from which to draw conclusions. These interviews were presented in the form of transcriptions and are listed in Appendix E.

3.4 CREDIBILITY AND ACCEPTABILITY OF RESEARCH

One of the biggest challenges confronting qualitative researchers is how to assure the quality and trustworthiness of their research (Tracy, 2010). Qualitative research differs from quantitative investigation in the lesser importance it attaches to traditional positivist criteria such as reliability, validity and generalisability. Whereas quantitative researchers value consistent, reliable measures in order to allow studies to be replicated, qualitative researchers, on the whole, argue that research situations, by their very nature, cannot be replicated (Tracy, 2010). Instead, their concern is to explore the uniqueness of people's accounts and to capture underlying social meanings. Of course it depends on the qualitative methodology you are adopting - and there are many! But often, for qualitative researchers, the questions at stake are: Has the social world been evoked in a credible or resonant way?; and, Can the findings be usefully applied more widely? (Tracy, 2010).

Credibility in qualitative research means the results of a qualitative study are believable and trustworthy, from the perspective of a participant or subject in the research itself (Koro-Ljungberg, 2010). Because qualitative research attempts to describe or explain the event, group or phenomenon of interest from the perspective of participants, the participants who form the subjects of the study are best situated to judge the credibility of the findings in a qualitative study (Koro-Ljungberg, 2010). Tracy (2010) suggests a series of steps to ensure a credible qualitative study. These steps include using well-established research methods, such as interviews, participant observations, document analysis and employing multiple research methods (triangulation) to study the same phenomena.

Researchers using any methodology must address potential issues of credibility in project design and research execution. McMillan and Schumacher (1993:386) suggest that, in an attempt to improve credibility and acceptability, attention should be paid to the researcher's role, informant selection, social context, data collection and analytical strategies. A discussion follows of the strategies that will be applied to enhance credibility and acceptability in this study.

a) Researcher's role

The choices made when adopting evaluative criteria are intertwined with the nature of the research that was conducted (in terms of its methodology, aims and assumptions). What is important then is to be transparent, to pursue what Kitto, Chester and Grbich (2008:244) call 'honesties' in research. Kitto *et al*. (2008) write that the researcher's social relationship with the participants is an important aspect that must be identified in a study. In this particular study, one already had a social status within the participants, which posed a threat to the credibility of the study. Therefore, ensuring that preconceived ideas and knowledge did not result in bias regarding the interpretation of research data was important. This was achieved by corroborating the findings by means of tape recorders, literal transcription of participants' responses and quotations from documents.

b) Informant selection

To ensure that future researchers contact informants similar to those contacted in this study, informants were purposively selected and are described as SGB members, mathematics curriculum advisors, principals of schools, Grade 12 mathematics teachers and students from public high schools in Vhembe District in Limpopo Province.

c) Social context

The social context in which interviews are involved and the interpersonal relations among group members may explain an individual's actions and meanings (Kitto *et al*., 2008). Thus the social context was described in terms of time, people or place for data analysis.

d) Data collection strategies

Rubin and Babbie (2008) recommend a triangulation process to eliminate biases that might result from relying exclusively on one data collection strategy, source or theory. In the study, the process entailed interviews, lesson observation and document analysis. The statements from respondents with the information in the biographical questionnaires, evidence from documents and observational records were then matched. Finally, the statements were checked for consistency with the theoretical framework established earlier.

e) Data analysis strategies

The themes or analytical categories offered by the researcher should fit the data. The researcher demonstrates this by writing clear, explicit accounts of how these categories evolved (Ballinger, 2006). The researcher needs to provide a retrospective account of how data were synthesised and identify strategies of data analysis and interpretation (Kitto *et al*., 2008). Data were analysed using the procedure for qualitative data analysis, which involved developing units, then categorising the unitised data by grouping them in terms of phenomena discovered in the relevant data and then grouping categories to form patterns. Schedules, a full list of units' meanings (unitised data), categories and patterns used for data analysis in the study are listed in the appendix. This reduced threats to both reliability and validity in qualitative research, which will be discussed later.

f) Analytical premises

Another way of guarding against incredibility and unacceptability is a clear description of the conceptual framework (Kitto *et al*., 2008). The literature review informed the study and germane findings were noted to allow for them to be integrated or contrasted. In future, other researchers who do similar studies can thus begin from similar analytical premises. Threats to credibility and acceptability could also be reduced in the data collection process.

For qualitative research, researchers must keep key aspects in mind (reliability and validity) before, during and after a research endeavor is completed in order to maximise its credibility (Koro-Ljungberg, 2010). Discussion of reliability and validity in qualitative research follows.

3.4.1 Reliability in qualitative research

Reliability in qualitative research refers to the consistency of the researcher's interactive style, data recording, data analysis and interpretation of participants' meanings from the data (Kitto *et al*., 2008).

Strategies that can be used in combination by qualitative researchers to reduce threats to reliability include verbatim accounts, low inference descriptors, multiple researchers, mechanically recorded data, participant researchers, member checking, participant review and negative cases (Ryan-Nicholls & Will, 2009:78). From this list a discussion of only those strategies that were applied in this study follows, i.e.:

i. Verbatim accounts

These are word-for-word accounts of interviews, transcripts and direct quotations from documents to illustrate participants' meaning. In this study a tape recorder was used during the interview sessions. Taped discussions were transcribed and are listed in Appendix E. The use of a tape recorder also helped to eliminate shortcomings that could result from memory loss.

ii. Low inference descriptors

This involves recording precise, almost literal, detailed descriptions of people and situations. The aspects to be considered are history, physical setting, environment and members' perceptions, amongst others (Gall, Borg & Gall, 1996:572). This information helps one to make an informed judgement about whether or not findings from a particular study are useful in understanding other situations (Gall *et al.*, 1996:572). Low inference descriptors provided an outline of the physical setting, a brief historical background and some significant events at each chosen school. Thus reliability was addressed by: providing the conceptual framework that forms the basis of this investigation; the use of triangulation and tape recordings. Reliability was enhanced further by describing the socio-economic status of the communities in which the schools were situated, the schools' broader context, the conditions of the buildings and the type of social relationships that prevailed.

3.4.2 Validity in qualitative research

Schwandt (1997) defines validity as how accurately the account represents participants' realities of social phenomena and whether or not the account is credible to them. On the one hand, Creswell and Miller (2000) assume that validity refers, not to the data, but to the inferences drawn from them. Writing about validity in qualitative enquiry is challenging on many levels (Creswell, Miller & Olander, 1998:474). However, there is general consensus that qualitative researchers need to demonstrate that their studies are credible (Creswell *et al.*, 1998). To this end, several authors identify common procedures for establishing validity in qualitative projects (e.g., Maxwell, 1996; Merriam, 1998). According to Creswell *et al.* (1998), qualitative researchers routinely employ member checking, triangulation, thick descriptions, peer reviews and external audits for establishing validity. Furthermore, the choice of validity procedures is governed by two perspectives: the lens through which

researchers choose to validate their studies and the researcher's paradigm assumptions (Creswell *et al.*, 1998). The following section comprises a discussion of the two perspectives.

3.4.2.1 The lens used by the researcher

When Creswell *et al.* (1998) refer to the lens, they mean that the researcher uses a viewpoint for establishing validity in a study, i.e. qualitative researchers use a different lens for validity to what they would use for quantitative studies. For example, one lens to determine the credibility of a study is the particular researcher, i.e. researchers determine how long to remain in the field, whether or not the data are saturated to establish good themes or categories, and how the analysis of the data evolves into a persuasive narrative (Creswell *et al.*, 1998). Altheide and Johnson (1994:489) refer to the interaction between researchers, the topic and the sense-making process, as "validity-as-reflexive-accounting".

Qualitative enquirers may use a second lens to establish the validity of their account, namely the participants in the study (Creswell *et al.*, 1998). The qualitative paradigm assumes that reality is socially constructed and is what participants perceive it to be (Krathwohl, 2004). Therefore, this lens suggests the importance of checking the accuracy of the representation of participants' realities in the final account (Creswell *et al.*, 1998). Those who employ this lens seek to involve participants actively in assessing whether or not the interpretations accurately represent them (Creswell *et al.*, 1998).

3.4.2.2 Paradigm assumptions

The lens that researchers use – their own, study participants', or individuals' external to the project – is not the only perspective that governs the choice of validity procedures (Creswell *et al.*, 1998). Researchers' paradigm assumptions or world views (Guba & Lincoln, 1994) also shape their selection of procedures. As suggested by Creswell *et al.* (2000:124):

> Quite different notions of what constitutes validity have enjoyed the status of dominant paradigm at different times, in different historical contexts, and under different prevailing modes of thought and epistemology.

Three paradigm assumptions, labelled by Guba and Lincoln (1994) as post-positivist, constructivist and critical, influence researchers' choice of validity procedures. A brief overview of the post-positivist paradigm assumption is advanced here. The post-positivist researcher assumes that qualitative research consists of rigorous methods and systematic

forms of enquiry (Guba & Lincoln, 1994). Identified by Denzin and Lincoln (1994:8) as the "modernist" phase of qualitative enquiry, this philosophical perspective emerged in social science research during the 1970s and continues today. According to Guba and Lincoln (1994), individuals who embrace the post-positivist position both recognise and support validity and actively employ procedures for establishing this validity by using specific protocols.

3.4.2.3 Validity within lens and paradigm assumption

There are nine different types of validity procedures within the lens and paradigm perspective, as illustrated in Table 3.2. This list is not exhaustive, but it includes those procedures commonly used and cited in qualitative literature (Guba & Lincoln, 1994).

Table 3.2: Validity procedures within qualitative lens and paradigm assumptions

Paradigm assumption/lens	**Post-positivist or systematic paradigm**	**Constructivist paradigm**	**Critical paradigm**
Lens of the researcher	1.Triangulation	4. Disconfirming evidence	7. Researcher reflexivity
Lens of study participants	2. Member checking	5. Prolonged engagement in the field	8. Collaboration
Lens of people external to the study (reviewers, readers)	3. The audit trail	6. Thick, rich description	9. Peer debriefing

From these nine validity procedures, the discussion now turns to triangulation and member checking, with a brief definition of each being given, as well as and the approaches for implementing each procedure, as these are the ones applied in this study.

a) Triangulation

Triangulation is a validity procedure in which researchers search for convergence among multiple and different sources of information to form themes or categories in a study (Creswell *et al.*, 1998). Denzin and Lincoln (1998) identified four types of triangulation:

across data sources (i.e. participants), theories, methods (i.e. interview, observations, documents), and among different investigators. As a validity procedure, triangulation is a step taken by researchers who employ only the researcher's lens; it is a systematic process of sorting through the data to find common themes or categories by eliminating overlapping areas (Creswell *et al.*, 1998). A popular practice for qualitative enquirers is to provide corroborating evidence collected through multiple methods (such as observations, interviews and documents) in order to locate major and minor themes (Creswell *et al.*, 1998). The narrative account is valid, because researchers go through this process and rely on multiple forms of evidence, rather than on a single incident or data point in the study (Creswell *et al.*, 1998).

b) Member checking

With member checking, the validity procedure shifts from the researcher to participants in the study (Creswell *et al.*, 1998). Bygstad and Munkvold (2007:33) describe member checks as "the most crucial technique for establishing credibility" in a study. It consists of taking data and interpretations back to the participants in the study so that they can confirm the credibility of the information and narrative account (Bygstad & Munkvold, 2007). With the lens focused on participants, the researchers systematically check the data and the narrative account (Creswell *et al.*, 1998). Several procedures facilitate this process. A popular strategy is to convene a focus group of participants to review the findings (Bygstad & Munkvold, 2007). Alternatively, researchers may have participants view the raw data (e.g. transcriptions or observational field notes) and comment on their accuracy. Throughout this process, the researcher asks participants if the themes or categories make sense, whether or not they are developed with sufficient evidence and whether or not the overall account is realistic and accurate (Bygstad & Munkvold, 2007). In turn, researchers incorporate participants' comments into the final narrative. In this way, the participants add credibility to the qualitative study by being given the chance to react to both the data and the final narrative (Bygstad & Munkvold, 2007).

In the present study, the nature of classroom observation and semi-structured interviews was such that the reality of the impact of the teacher's instructional practices and the principal's instructional leadership on TLM was reflected in a natural setting. Therefore, validity procedures inherent in the study design, such as triangulation across data sources, theories and methods were used. The primary lens, however, was that of the participants in the study,

and the study became more reflexive, acknowledging the inseparability of the researcher and the process of enquiry. As for paradigm stances, the study aligned closely with the use of systematic procedures. Therefore, the study resonated with the post-positivist perspective and engaged in member checking to ensure that the interpretation and concepts had mutual meanings between study participants and the researcher (McMillan & Schumacher, 1993).

3.4.3 Validity in data collection instruments

Content validity, criterion validity and construct validity are measures that are used to assess the validity of data collection tools (Peat, 2002). From this list, a brief overview of content validity is advanced here because of its applicability to the research instruments used for this study.

Content validity refers to whether or not a tool appears to others to be measuring what it says it does; face validity is a simple form of content validity (Carter & Porter, 2000). In order to establish the content validity of a measuring instrument, the researcher must identify the overall content to be represented. However, identifying the overall content is not an easy task. It is, therefore, usually suggested that the researcher asks a few people to check whether or not the tool covers all areas. Alternatively, a more rigorous way to assess content validity is to ask recognised experts in the area of study for their opinion on the validity of the tool (Carter & Porter, 2000). By using this method, the researcher obtains a group of items that are representative of the content of the trait or property to be measured. For example, in the case of researching the knowledge of teachers about a new curriculum, a group of curriculum and teacher education experts might be asked to identify the content of the test to be developed (Carter & Porter, 2000).

During the research instruments developmental stage, three mathematics teachers with more than six years' teaching experience were requested to check whether or not the research instruments, semi-structured interviews and observation inventory, were valid for purposes of this research study, before piloting them. Bearing in mind that each school has its own social structures and tends to organise instruction according to prevailing local conditions, focus was on what teachers, principals, students and curriculum advisors were doing to better students' achievement levels in mathematics at these different schools. So the discussion of the results of the pilot study (see Section 3.5 below) with two recognised experts in mathematics education was done to decide whether or not to maintain or adapt the semi-

structured interviews and observation inventory. The experts suggested that semi-structured interviews should target the identified adverse issues. There was no adjustment made regarding the observation inventory, since it was adopted from Gagné & Briggs's (1974) assumption on designing instruction (see Section 3.3.2). The instruments were adapted, based on the identified adverse issues arising during the pilot study (see Section 3.5 below). Before implementation of the adapted research instruments, they were appraised by two recognised experts in mathematics education.

3.4.4 Concluding remarks on reliability and validity

From the exposition above, it can be deduced that addressing threats to reliability and validity in qualitative research ensures that other researchers view one's work as credible. However, *reliability in research instruments* (the consistency of the means of data collection) is largely irrelevant in the case of qualitative research (Finlay, 2006c). In this regard, the following has been discussed: reliability in qualitative research (the consistency of the researcher's interactive style; data recording; data analysis and interpretation of participants' meanings from the data); validity in qualitative research and content validity of the measuring instruments.

By definition, qualitative research does not seek to be consistent or to gain consistent results; rather it seeks to elicit the responses of a participant at a specific time and place and in a specific interpersonal context (Finlay, 2006c). Thus, qualitative research takes the position that situations can never be replicated exactly. For instance, what emerges in an interview is seen as contingent on the researcher's approach and the specific interviewer-participant relationship and context (Finlay, 2006c). Another researcher, or even the same researcher, interviewing the same participant at a different time or place would not elicit exactly the same 'story'. Besides, the degree to which research truly measures what it was meant to measure (validity) rests upon the assumption that the phenomenon being investigated possesses 'reality' in an undisputed, objective sense. Qualitative researchers, in general, view this as inappropriate (Finlay, 2006c). Given the diversity of the social world, qualitative researchers argue, it is erroneous to assume the existence of one unequivocal reality to which all findings must respond. They ask instead: whose reality is the research addressing?

Moreover, qualitative research – by definition – involves subjective interpretations (often delivered by both participants and researchers) (Finlay, 2006c). If one accepts that

interpretation cannot be excluded from the research process, it follows that any one analysis can only be presented as a "tentative statement opening upon a limitless field of possible interpretations" (Brown, 2010:232). Thus qualitative researchers do not seek to extrapolate statistical findings from a specified sample to the wider population (generalisability). Instead, they are concerned to show that findings *can* be transferred and *may* have meaning or relevance if applied to other individuals, contexts and situations (Tracy, 2010). Thus qualitative researchers may well celebrate the richness and depth of data that can be obtained from just one participant, who has been purposely approached; and qualitative researchers argue that the experimental concern to obtain a large randomised representative sample misses their point entirely (Tracy, 2010).

It also became clear that, as meanings are elicited in an interpersonal context, knowledge claims must be tested and argued in a dialogue with others, including participants, the research supervisor or a wider academic community. Furthermore, qualitative research methodologies vary considerably in their aims and epistemological assumptions and these, in turn, shape the methods or procedures employed and the evaluation criteria used (Finlay, 2006b). The use of a multiple-strategy approach increases 'conceptual density', while focus groups with participants and consultation with a colleague allow exploration of the 'credibility' of findings (Finlay, 2006a). Ballinger (2006) recommends considering the *role of the researcher* and ensuring that this is accounted for in a way that is consistent with the research methodology.

Mindful of differing assumptions and commitments arising from chosen methodologies, rigour was operationalised through member checking and triangulation. It was also highlighted that research needs to be '*trustworthy*' (a term often used in place of 'validity' in the qualitative researcher's lexicon), in the sense of being able to demonstrate both *rigour* (process) and *relevance* (end product). Therefore, the integrity of the research process and the quality of the end product would seem to require evaluation criteria of quite a different order – criteria that are *responsive to qualitative research ideals and goals* (Tracy, 2010).

It also became clear that reliability and validity had been addressed in the research design, as well as in data collection strategies. The aim of the study, however, was not to generalise the findings, but to extend understanding of a phenomenon. The application of a qualitative method in the study was therefore useful, since it contained detailed descriptions that would enable others to understand similar situations and extend these understandings in subsequent

research (Morse, Barrett, Mayan, Olson & Spiers, 2002:6). Therefore, external validity depends on "translatability" and "comparability" (Morse *et al*., 2002). Comparability refers to the degree to which the research design is adequately described, so that researchers may use the study to extend the findings to other studies. Translatability, on the other hand, is the extent to which other researchers understand the results, given the theory and procedures underlying the study (Morse *et al*., 2002). Therefore, to establish both comparability and translatability, the study based the theoretical framework on an extensive literature study.

3.5 PILOT STUDY

What is a pilot study? A pilot study is a mini-version of a full-scale study or a trial-run done in preparation for a complete study. It can also be a specific pre-test of research instruments. The pilot study will thus follow after the researcher has a clear vision of the research topic and questions and the techniques and methods which will be applied (Krathwohl, 2004).

The pilot study in the current research can be defined as mainly a try-out of the semi-structured interviews and lesson observation inventory. The pilot study was a feasibility study, a pre-testing of research instruments and also a process of personal growth towards a more polished interviewer and observer.

Data collection was preceded by a pilot study entailing the use of the observation inventory and open-ended questions in the semi-structured interview schedules at two schools in the MWC of the Vhembe District. The participants were eight Grade 12 mathematics students, two Grade 12 mathematics teachers, two principals and a mathematics advisor. The use of schools in Vhembe District, both in the pilot study and main study, did not threaten the validity of the study, because the study is more descriptive and does not require any interaction of variables.

The outcomes of the pilot study were divided into two categories, namely *practical considerations* and *assessment of instruments*. The practical considerations that needed attention included: time limit per interview session; and keeping the interview session active. The time limit per interview session was set at 10-20 minutes initially. It emerged that this time limit was much too short and the time allowed was changed to 20-30 minutes in the middle of the pilot study; thereafter the interview process was satisfactory in terms of courtesy, clarity, pace and relevance of the content. In terms of assessment of instruments, piloting of the research instruments resulted in identification of challenges militating against

implementation of the reform-oriented practices in TLM, as emerged from the teacher, student, principal interviews and lesson observations. However, the issues emerged, not because the interview questions targeted them, but because the interviewees revealed the adverse conditions under which they worked. The negative issues raised related to over-crowded classrooms, poor student attitude to mathematics, the progression criteria for grades, a lack of parental involvement in mathematics learning, a weak foundation in earlier grades, a shortage of qualified mathematics teachers, workshops out of touch with classroom situations and a lack of curriculum management. On the basis of these issues, the most important finding was that the interview questions had to be adapted to create an opportunity to tap data, based on the issues identified during piloting, before being implemented in the main study. The adaptation of the main research instruments formed the basis for further consultation with experts in mathematics education, prior to implementation in the main study. Feedback from the mathematics education experts was positive regarding the operational feasibility, clarity, length, content and relevance of the main instruments.

3.6 DATA COLLECTION

Although the unit of analysis was Vhembe District schools in Limpopo Province, the research programmes were designed to capture the multi-dimensionality of the concept of capacity (see Section 2.2.2). The whole project was therefore divided into sub-studies that focused on one or more of the aspects raised in the research questions. For example, in an attempt to answer the question, *How mathematics teachers identify, mobilise and activate resources for mathematics instruction?* Focus was on: teachers and the teaching of mathematics; and on students and the learning of mathematics in schools. Focus also had to include issues of curriculum implementation, a culture of learning mathematics, and the support rendered to teachers by students, principals and mathematics curriculum advisors. It is on this basis that data were collected using interviews, document analysis and lesson observation. The process of data collection was guided by the various principles developed in the framework for instructional capacity, i.e.:

1) First principle

The advanced premise was that instructional capacity is multi-dimensional. It encompasses both the individual and the social or organisational components (Corcoran & Goertz, 1995). At the individual level, the study needed to investigate the resources contributed by teachers

and students, and the physical materials and intellectual tasks (curriculum subject content) within mathematics.

Starting with the teachers, issues such as: teachers' knowledge and skills; their attitude to content, to the students and towards innovation in general; and their sense of self as teachers and as lifelong students of mathematics were analysed. In terms of techniques, interviews and lesson observations were used to a large extent.

In the case of the students, their attitudes to the subject matter, to the teaching and learning processes, their engagement with teaching and learning, and their sense of self as students of mathematics were probed. Focus group interviews and lesson observations were used.

Finally, it was important to get a sense of the physical resources or materials available for instruction in mathematics, e.g. textbooks, manipulatives and other facilities available for learning. The aim was to understand how these resources were organised and used to construct a school's capacity. Document analysis, observations and interviews were used for this analysis.

However, materials in the Cohen and Ball (1999) sense include intellectual materials or "the tasks, the problems and the discourses" through which content is represented in a particular classroom. The notion of what mathematics meant in these particular classrooms and schools and how that added to or subtracted from each school's construction of capacity for quality instruction was probed through lesson observations, document analysis (including samples of students' work) and interviews.

2) Second principle

In addition to being multi-dimensional, capacity is not fixed, but dynamic. It is constructed and reconstructed at the point of interaction between the three components of the instruction unit: teacher, students and materials. That is, capacity is constructed differently in each classroom as the teacher interacts with a particular group of students in terms of the materials and as the students interact with the content. This variability in capacity was captured through observation of classroom processes in mathematics teaching and learning at the schools.

3) Third principle

Coupled with the classroom aspects of the study, focus was also on the social or organisational effects and arrangements that shape the capacity to create quality instruction in mathematics. This included the subject department, staff networks within the school, networks with other schools and higher education institutions, the organisation of time or scheduling, the organisation and use of physical materials, and (most importantly) the school's leadership for instruction. Observations, document analysis and interviews were used.

To summarise, data collection for the current study involved four major components, i.e.:

- A classroom investigation of capacity within mathematics.
- A social networks analysis and institutional culture study relating to TLM.
- A study of challenges teachers face as they relate to instruction in mathematics.
- A study to understand the influence of principals, teachers, students and mathematics curriculum advisors on schools' instructional capacity in mathematics.

Added to the analysis of documents on the structure and organisation of instructional capacity, naturalistic observations was also made of: how the system worked; as well as the key resources at each level and how these were constructed and organised to provide the instructional capacity at school level. That is, while observing the organisation of capacity at each secondary school, the study also sought to produce descriptions of the practices that exemplified the unique organisation of resources and materials at each school.

3.6.1 Qualitative research context

3.6.1.1 Data collection methods

The study was conducted at ten public secondary schools in the Vhembe District in Limpopo Province of South Africa, using three qualitative data collection methods, namely observation, interviews and the analysis of written documents. Five mathematics curriculum advisors, the principal, a sample of four students and a Grade 12 mathematics teacher were interviewed at each school. The principal and teachers were also asked to fill in a biographical questionnaire (see Appendix C). At each school, written documents, as listed in the checklist (see Appendix F), were examined.

3.6.1.2 Larger context of the selected schools

The ten secondary schools selected fall under the Vhembe District of Limpopo Province in South Africa, which consists of schools in rural villages and peri-urban townships. All ten secondary schools selected were established prior to the 1994 democratic elections in the country and could be said to belong to what is commonly referred to as "previously disadvantaged schools", even though many schools that were established post-1994 are still economically deprived. The DoE is faced, not only with the challenge of redressing past inequalities, but also with that of (re)constructing the culture of teaching and learning for the realisation of quality instruction in mathematics. It can also be presumed that the quality of instruction in mathematics in schools across the Vhembe District will differ, depending on the impact of various factors on each particular school.

Since its inception in 1994, the post-apartheid government has engaged in a number of initiatives to transform its education system (see Section 1.1). It is rather disturbing to note that more than fifteen years into the new dispensation, attainment of quality instruction in mathematics still remains the greatest challenge in most schools in the country.

3.6.1.3 Educational situation in the selected schools

Ten secondary schools situated in rural villages were selected based on the quality of instruction in mathematics, as measured by the pass rate in the Mathematics matriculation examinations of 2008 and 2009. At this juncture, it is imperative to explain briefly how instruction relates to pass rate.

First and foremost, instruction refers to the arrangement of a learning environment (teaching incident) in an effort to maximise the probability that students interacting with this environment will learn what the instruction intends (Boston, 2002:2). Carr *et al.* (1998:5) mention that constructivism (see Section 2.3.1.2) emphasises students' activities and how they construct knowledge as a process of making sense and giving meaning. Constructivist instruction should, therefore, offer opportunities for cooperative learning and efforts should be made to implement instructional strategies that enable students to collaborate and socially negotiate their interpretations of events and the information presented within the learning experience in the classroom (Boston, 2002:2). Boston sees instruction arranged in this way as an opportunity to improve and enhance students' knowledge, insight and understanding.

The matriculation examination questions are formulated, not only to assess knowledge (the recall of information), but also to gauge: insight and comprehension (to understand and make sense of); application (use of information in novel situations); analysis (to see patterns, order and make connections); synthesis (make generalisations and predictions from facts); and evaluation (to make choices based on logical arguments of competency) (Anderson & Krathwohl, 2001). So, when 60% or more of a group of students passes the examination (as is the case for School 1), the assumption is that the teaching and learning process was effective, and thus too the relationship between instruction and pass rate.

Of the ten secondary schools selected, schools 1 - 5 are perceived as schools where the quality of instruction in mathematics is considered good, as measured by high pass rates in the Mathematics matriculation examination. They are referred to as high-performing schools. The quality of instruction in mathematics in secondary schools 6 - 10 could be described as below average, as measured by low pass rates in the matriculation examinations. These are referred to as low-performing schools. School 8, on the other hand, was declared dysfunctional in 2009 by the DoE (as revealed by the school principal), after obtaining an overall pass rate of 20%. It is disturbing to also note that School 6, which always took pole position among all 13 secondary schools in MWC (in terms of overall pass rate since 2000), has been showing a progressive decline since 2008, taking positions 3, 5, 11 and 10 in 2008, 2009, 2010 and 2011 respectively.

3.7 ETHICAL ISSUES

McMillan and Schumacher (1993:398) cite potential ethical dilemmas, such as: informed consent dialogue; confidentiality and anonymity; deception, privacy and empowerment; as well as harm, caring and fairness. A discussion of these ethical dilemmas follows.

3.7.1 Informed consent dialogue

This entails obtaining permission to enter the field. Letters were written to the district managers and the principals to obtain permission to carry out the study at the selected sites. The intended use of the data was explained in the letters and to the participants. First, it was pointed out to the participants that participation was voluntary. The participants were allowed to choose the time and place for their interviews. It was ensured that there was no infringement on teaching and learning processes and being judgemental and interfering was avoided. Also insincerity and manipulation was guarded against.

3.7.2 Confidentiality and anonymity

Confidentiality of interviewees' data is important. Private information obtained from respondents might make others feel unhappy and strain relationships (McMillan & Schumacher, 1993:399). In this study, confidentiality and anonymity was imperative since teachers were expected to comment on the instructional leadership of principals and mathematics subject advisors. If informants are identified, consequences might be harmful in that the seniors might be offended and abuse their position of power, to the disadvantage of junior colleagues (McMillan & Schumacher, 1993:399). Therefore, it was important to disguise features of the settings in order to make individuals indistinguishable from others.

The names of the schools and informants were coded. The informants were also assured of anonymity and confidentiality. Since letters of permission received from principals to use the schools bore the schools' letterheads, they were omitted from the appendix to protect the identities of respondents. It was pointed out to all participants that the results were strictly for purposes of the study only.

3.7.3 Deception, privacy and empowerment

It sometimes happens that even participants who have been fully informed and who subsequently cooperated sometimes feel betrayed when they read research findings in print (McMillan & Schumacher, 1993:399). What stands out here is that there are no guarantees that observing ethical issues will always result in happy endings. This implies that the researcher should, in addition to being sensitive to ethical issues, also highlight the influence of the participants in the success of the study (McMillan & Schumacher, 1993:399). Their sense of importance may compensate for the inconvenience they may suffer (McMillan & Schumacher, 1993:399). In this study, the participants were thus informed accordingly and encouraged to discuss any problems they experienced during the interviews.

3.7.4 Harm, caring and fairness

In this study, the focus was on the five dimensions of instructional capacity. McMillan and Schumacher (1993:400) cite a potential ethical problem in the principle of persons being treated as ends, rather than as a means to an end. This occurs when the researcher is only concerned about the results, regardless of any personal humiliation that people may experience, or damage to interpersonal relationships (McMillan & Schumacher, 1993:399).

The nature of relationships in school settings is such that people are likely to blame one another, especially since line function is hierarchical. Therefore one has to be caring and fair. All participants were encouraged to focus on making a meaningful contribution to the improvement of TLM, rather than using this as an opportunity to expose other people's weaknesses.

On the basis of the discussion above, one has to be always wary of the potential ethical dilemmas at all stages of the research process. A written request to carry out the study in schools was sent to departmental officials, stating the aim of the research. Anonymity and confidentiality were assured in the request. Also all the stakeholders were assured that the collected information was solely for purposes of the study. A copy of a permission letter is included in the appendix.

3.8 CONCLUSION

This chapter focused on the methodology employed in the study. The qualitative approach was chosen because it allowed for the establishment of the commonalities and the unique features of instructional capacity, as it was constructed and practised in a variety of settings and organisations within Malamulele Circuit schools.

The development of data collection instruments (interviews, observations and document analysis) used in the study was discussed. It was indicated that additional information was obtained from biographical questionnaires completed by principals and educators to corroborate the findings. The site selection and sampling procedures that were used to choose information-rich cases were also explained.

The process of data collection was based on the principles that instructional capacity is multi-dimensional, dynamic and depends on the organisation and use of resources. Reliability and validity in qualitative research was explained to ensure that other researchers view the research as credible. Content validity of the data collection instruments was also discussed. In an attempt to improve credibility and acceptability, attention was paid to the researcher's role, informant selection, social context, data collection and analytical strategies.

Mindful of differing assumptions and commitments arising from chosen methodologies, rigour was operationalised through member checking and triangulation. In an effort to avoid problems related to ethical issues, informed consent, confidentiality and anonymity, harm,

caring and fairness were all taken into consideration. Empowerment of the participant as a way of encouraging participants to overlook a loss of privacy in favour of the valuable contribution they were making by their participation was also discussed.

The next chapter will focus on data analysis.

CHAPTER 4

DATA ANALYSIS

4.1 INTRODUCTION

In the previous chapter, the research methods and techniques used in this study were discussed. This discussion entailed qualitative data collection strategies, site selection, sampling, credibility, a pilot study and ethical issues.

This chapter focuses on data processing and the problems encountered in data collection. First, the problem encountered in data collection concerning the research participants is highlighted. This is followed by the analysis of classroom observational data, written documents and interview data. Patterns identified from data analysis are then presented. The findings deduced from the analysis and the interpretation of these findings will be discussed in Chapter 5. The next section is a discussion of the problems encountered.

4.2 PROBLEMS ENCOUNTERED IN DATA COLLECTION

A plan was in place to interview at least one school governing body (SGB) member at each school, but this was not possible, as none of them could avail themselves for the interview. Nevertheless, the other participants used in the study (see Section 3.2.2.2) managed to provide adequate data for purposes of the study. Thus the results were not affected.

4.3 DATA PROCESSING

4.3.1 Classroom observation data

The purpose of this part of the study was to describe the teaching of mathematics in classrooms. It was important to know how efficiently the teacher uses his/her own mathematical and pedagogical knowledge to successfully implement the lesson. Even though there are other important aspects of teaching (e.g. time students spend doing work while seated, recitation activities, group work, idle time, etc.) to consider when observing classroom lessons, focus was on TLM because of its promising links with teacher knowledge and student outcomes (Kazima, Pillay & Adler, 2008). The way lessons were measured in this study was designed to capture instructional practices in mathematics vis–à–vis collaborative work, problem solving relevant to real life situations, classroom discourse, hands-on activities and so forth. Perhaps in response to the need to better explain the

mathematical aspects as well as mathematical pedagogy harnessed during lessons observations, attention is given to reporting observed teachers' knowledge during instruction. So the question to answer is: What is the level of observed mathematical and pedagogical knowledge of the teacher during the lesson?

4.3.1.1 Observed teacher's knowledge while teaching

To characterise the observed teachers' knowledge in a lesson, focus is on three categories. The work of Shulman (1986) forms the basis of these categories. These include:

- *Grade level mathematics knowledge* - the presence of computational, linguistic and representational accuracy for mathematics at the grade level being taught. I take into account any mathematical errors during instruction.
- *General pedagogical knowledge* - The use of general instructional techniques beyond the lecture mode. Elements include how well the teacher has engaged all students, his/her use of proper classroom management techniques and the quality of instruction materials.
- *Mathematical knowledge in teaching* - The degree to which the teacher can appropriately integrate the use of instruction techniques with the mathematics concept being taught and its effectiveness for learning.

Together, these three analytical elements made it possible to consider the mathematical meaning of what is being taught. These elements also allowed access to what the teachers knew and how they applied this knowledge in the classroom. This in turn makes for some useful linkages between lesson analysis and teacher interviews. Of course what is observed in one lesson does not measure the entire body of knowledge a teacher has in mathematics, or any of the kinds of knowledge. The purpose of looking at the teacher's knowledge during these lessons is not to characterise the entire knowledge of a teacher: the purpose is to measure how well the teacher uses these specific knowledge forms (*mathematical and pedagogical)* in a particular lesson.

To capture the presence of the three different components for observed teacher's knowledge, a coding system was used for lessons. After observing a particular lesson, a code of 'present' (P) or 'not present' (NP) was adjudged for each component that defines observed teacher knowledge, as mentioned above. If the component was observed *at least once* during lesson, a code of P was adjudged. Post-lesson interviews with teachers were done to allow the

validation of the coding system and also to enrich the understanding of teaching practices in these schools. In addition, an overall evaluation of teaching quality observed in the lesson was assigned using the following scale: 1 (low); 2 (medium); or 3 (high). These ratings were a holistic composite of the three components described above.

4.3.1.2 Results

A result that stands out is the large class sizes in the schools in the sample: on average 44.9 and varying from 19 to 68 (standard deviation equal 18.0). The length of classes observed were almost all 30 to 35 minutes long. At each of the ten public secondary schools in Malamulele West, one lesson was observed. All lessons were video-recorded. The ten schools catered for boys and girls, all of whom were black. With respect to what teachers and students do in the classroom, a typical mathematics lesson in a high-performing school's twelfth grade classroom is characterised and then for a low-performing school.

Data collection plan also involved paying attention during the classroom observation to the issue of who talked to whom, as well as the teacher's role. In almost all the lessons observed at the five high-performing schools, the teachers employed a teaching pattern consisting of four phases: whole-class discussion, pair work, reporting and summing up. There was no deviation from this teaching pattern. **EXTRACT 1** from classroom observations (Transcript 1) provides evidence of fairly exciting reform-oriented mathematics instruction.

EXTRACT 1: School 1

School 1 is situated in a small, but expanding, village. It had an enrolment of 603 students at the time of the study. There were 25 students doing mathematics in Grade 12. T1[1] has been teaching mathematics for eight years and has been teaching at this school for six years. He teaches mathematics to Grades 11 and 12 and holds a teacher's diploma and an ACE[2]. The matriculation Mathematics pass rates for 2008-2011 are given in Table 4.1.

[1]The ten teachers involved in the study were coded according to the school number, i.e. from 1-10.
[2] Advanced Certificate in Education (ACE), NQF level 6 in the HEQF (equivalent to a first degree).

Table 4.1: School 1's matriculation Mathematics pass rates for 2008-2011

Year	Whole school Enrolment	Grade 12 students per class	Number who passed	% pass rate
2008	307	20	14	70
2009	332	19	13	68.4
2010	456	23	15	69.6
2011	603	25	20	80

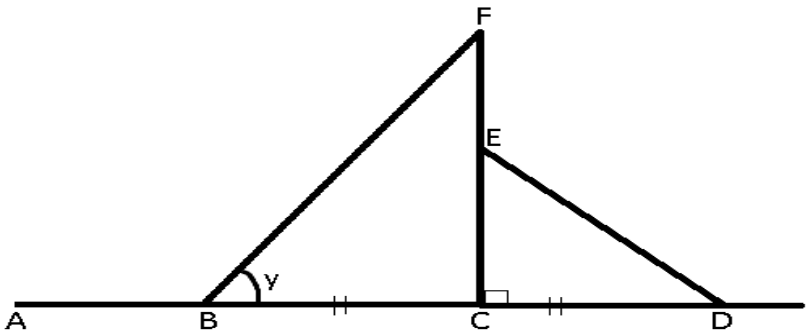
T1 was working on the lesson in trigonometry. It was learnt from the teacher that students were revising the two methods (Pythagoras' theorem and trigonometric ratios) of solving right-angled triangles done in Grade 10, in preparation for the solution of problems in two or three dimensions (LO 3: AS 6), which was scheduled for 11-29 April 2011 according to the Grade 12 Mathematics work schedule 2011 (see Appendix H). Students sit two to a desk in class. Since there were 25 students, there were 12 groups, with one group of 3 students. The classroom discourse reflected a student-centered approach, in that there was interpersonal exchange among students in the learning process facilitated by the teacher (as evidenced below (Transcript 1)). In the lesson, students were asked to work on the following problem in pairs:

(In the diagram, ABCD is a straight line. Given that, $CE = 3EF = \frac{BD}{2}$, find the value of $cos\ y$. Transcript 1 forms part of this lesson.)

Transcript 1

Lesson in trigonometry (March 2011)

1 Teacher: Read the question carefully. $CE = 3EF$. What does this mean?



2 Student-1: The length of CE is three times that of EF.

3 Teacher: Then, we have $3EF = \frac{BD}{2}$. How do we solve this problem? Someone to come and do the problem on the chalkboard.

4 Student-2: [Writes $\frac{BD}{2} = 3EF$.] Now, these are $3EF, 4EF\ and\ 5EF$ [pointing at sides $BC, CF\ and\ BF$ respectively]. We use Pythagoras' Theorem.

5 Student-3: How do we find $cos\ y$? [Without being given the platform to talk.]

6 Student-2: This is cos. So, adjacent divided by hypotenuse [pointing at the sides $BC\ and\ BF$ respectively].

7 Student-3: $\frac{3}{5}$

8 Student-4: Again, how do we find $cos\ y$?

9 Student-2: [Writes $CE = 3EF, 3 + 1 = 4$. So $CF = 4EF. 3EF = \frac{BD}{2} = BC$]. The sides of the right-angled triangle BCF are 3, 4 and 5 by using Pythagoras' Theorem [pointing at sides $BC, CF\ and\ BF$ respectively].

10 Student-4: Ok… so, $cos\ y = \frac{3}{5}$ [nodding his head in realisation]

11 Teacher: Ana (Student 2), what is your final answer?

12 Student-2: [Writes $cos\ y = \frac{3}{5}$]

13 Teacher: Can you explain to the class how you got it?

14 Student-2: [Writes $BC = 3EF, CF = 3EF + EF = 4EF$]. Applying Pythagoras' Theorem to triangle BCF… [Writes $BF = 5EF$,

$$cos\ y = adjacent\ divided\ by\ hypotenuse = \frac{3}{5}$$]

Student 2 explained the solution to student 3 (6) and student 4 (9). She reorganised her understanding and explained this more clearly to student 4 (9). She improved her explanation to the class (14). Hence, responses from students evolved from brief phrases or single disconnected sentences (4, 6 & 7) to expanded explanations that made sense (9 and 14). Next, the teacher put the complete burden on the students to explain and justify their solutions (13), as well as to comment on the contributions of other students (5 and 8). The teacher allowed the students to explore for themselves the mathematical ideas and gave them time to think, calculate and provide answers (4 and 6). Despite the fact that the lesson went smoothly, it was rather difficult to ascertain whether or not all students had understood. However, in post-observation conversation with the teacher of school 1, the teacher said:

T1 "…besides checking the students' class and homework books, I often give them a weekly test, which helps me to establish whether they had understood…"

On the whole, the lesson was timed and observations were that about a quarter of the lesson time was teacher-led, in which the teacher was presenting the content to the whole class. Half the lesson was seated work and the last quarter was solving problems at the chalkboard. On average, of the five high-performing schools' lessons timed: 32% of the time was teacher-led, where the teacher talked about mathematical content; 48% was group seated work and 20% was solving problems at the chalkboard.

A typical mathematics lesson in low-performing schools' twelfth grade classroom can now be characterised. In contrast to the pattern of teaching described above, teacher-talk dominated most of the observed lessons in the five low-performing schools, even though students had some knowledge of the content that was being taught. Below is **EXTRACT 2** from classroom observations (Transcript 2) at a low-performing school, which serves to illustrate a pattern in how teachers taught content throughout the classroom observations at low-performing schools.

EXTRACT 2: School 6

School 6's buildings were still intact, but graffiti defaced the classroom walls. The school had an enrolment of 753 students and there were 66 Grade 12 students doing mathematics in 2011. The matriculation Mathematics pass rates for 2008-2011 are given in Table 4.2.

Table 4.2: School 6's matriculation Mathematics pass rates for 2008-2011

Year	Whole school Enrolment	Grade 12 students per class	Number who passed	% pass rate
2008	468	43	15	34.9
2009	668	58	13	22.4
2010	745	68	13	19.1
2011	753	66	16	24.2

T6 had a teacher's diploma and four years' teaching experience. T6's general perception was that the principal concentrated too much on Grade 12 students, to the extent that an English teacher was teaching mathematics in Grades 8 and 9 (with 80 students in a class) and that the number of students in a class prevented much teacher-student interaction.

The teacher was working on a lesson on solving quadratic equations. Transcript 2 is part of this lesson.

Transcript 2

Lesson on solving quadratic equations (January 2011)

Teacher:

1 Today we are going to solve quadratic equation [writes $ax^2 + bx + c = 0, (a \neq 0)$].

2 We use the following quadratic formula to find the solutions to quadratic equation above [Writes $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$].

3 Now let us work together the following examples [writes copying from the November 2008 past examination mathematics paper: e.g. solve the following equations:

$$a)\ \ x^2 - 5x + 4 = 0$$

$$b)\ \ x^2 - 3x - 3 = 0]$$

4 To be able to use the formula [shows $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$], we identify the values of a, b, c in the given quadratic equation [writes, copying from the memorandum]:

Solution

$a)\ \ a = 1;\ b = -5; c = 4.$

So $$x = \frac{-(-5) \pm \sqrt{(-5)^2-4(1)(4)}}{2(1)} = \frac{5 \pm \sqrt{9}}{2}$$

$$\therefore x = 4\ or\ 1$$

$b)\ \ a = 1;\ b = -3; c = -3.$

So $$x = \frac{-(-3) \pm \sqrt{(-3)^2-4(1)(-3)}}{2(1)} = \frac{3 \pm \sqrt{21}}{2}$$

$$\therefore x = 3.79\ or\ -0.79]$$

5 Now, in your classwork exercise books, write the following classwork [writes copying from the November 2010 past examination mathematics paper: Classwork

$$a)\ \ x^2 - 8x + 12 = 0$$

$$b)\ \ 3x^2 - 2x - 4 = 0]$$

6 [Teacher moved around comparing what students were writing to the memorandum. Time did not permit the teacher to prompt students to report their solutions to the class.]

Through a teacher-dominated style of classroom discourse, the teacher copied two examples from the 2008 past examination mathematics paper memorandum on to the board. Students copied these examples into their exercise books. Thereafter, two quadratic equations from 2010 past examination mathematics papers were written on the blackboard for students to do on their own by following the examples given.

It would have been preferable for the teacher to start by discussing the methods that students had used to solve quadratic equations in the past (the method of factorisation and the method of completing the square). After that, he could have asked the students to solve an equation like $2x^2 - 3x + 4 = 0$ using the method of completing the square because factorising is not possible, and then letting students attempt to find the solutions to $ax^2 + bx + c = 0$ (the general form of all quadratic equations) by completing the square (leading to the quadratic formula, $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$, for solving all quadratic equations in real number set).

When I asked the teacher in **EXTRACT 2** why his lesson was teacher-dominated and why he taught quadratic equations in January 2011 (content covered in Grade 11), he said:

> "… I could not complete this content in 2010 … On the other hand and to be frank with you, actually we as teachers normally try to encourage active participation from students, since it is something that has been emphasised by our Department … But, somehow, I think because of the time factor, we teachers end up solving the problems for our students in order to cover all the content …"

Most of the teachers who engaged in the teacher-dominated style of discourse expressed the belief that they had limited time and that covering the content efficiently must take precedence over student learning with understanding (e.g. see **EXTRACT 2** above). This assertion simply indicates that these teachers were unable to maintain the "tension" between simultaneously covering the content and attending to student understanding.

On the whole, the lesson was timed and observations were that about two-thirds of the lesson time was teacher-led, in which the teacher presents the mathematical content to the whole class. The other third was seated work. On average, of the five low-performing schools lessons timed: 67% was teacher-led, where the teacher talked about mathematical content; 33% was seated work; and students were more likely to be seated three to a desk.

It was noted that in low-performing schools, more time was spent on whole class teacher presentations and on seated work, with less time spent on recitation. In high-performing schools, much of recitation time was mixed, with teacher-led talking/or other students questioning and students were more likely to be seated two to a desk. Analysis of teaching of content is now given attention.

The mathematics content observed in the entire set of lessons was distributed between three major mathematical areas, i.e. number concepts and operations: geometry; and measurement. Table 4.3 summarises the results according to the three components of teacher knowledge in the lessons observed.

Table 4.3 Percentage of lessons in which each component was observed

Observed teachers' knowledge	**Per cent of lessons**	
	Low-performing schools	High-performing schools
Grade level mathematics knowledge	93.4	95.2
General pedagogical knowledge	43.6	72.3
Mathematics knowledge in teaching	23.7	88.5
Total lessons	**5**	**5**

Teacher's observed knowledge

In this part of the analysis, to classify teacher knowledge, attention is given to lesson observations. However, classifying teacher knowledge based on lesson observation is a novel approach, with few antecedents (Sorto, Marshall, Luschei & Carnoy, 2009); and implementing it represents a number of challenges. It clearly requires mathematics education experts to classify the teacher's knowledge, based on his/her actions and choices in the classroom. For *content knowledge,* there are a number of possible 'clues' for assessing what the teacher knows. Careless mistakes when teaching operations or procedures, or more serious misconceptions about underlying concepts, are each indicators of content knowledge deficiencies (Sorto & Sapire, 2011).

Once again, a trained expert in the subject, with extensive experience of observing teachers, is needed to classify the teacher's *pedagogical knowledge* (Sorto *et al*., 2009). Elements

include how well the teacher has engaged all students, his/her use of proper classroom management techniques, and the quality of instruction materials (Sorto & Sapire, 2011).

The third and final domain of knowledge is formed by integration of the two previous knowledge areas. This *mathematics knowledge in teaching* is not necessarily separate knowledge, but it is demonstrated in the class by how well a teacher uses mathematical and pedagogical knowledge to help learners learn mathematics (Sorto & Sapire, 2011). Table 4.3 shows the percentage of teachers who demonstrated knowledge in each of the categories of knowledge described above.

For the mathematical knowledge category, teachers were coded according to demonstrated knowledge of mathematics by correctness in their written and spoken mathematical statements. Table 4.4 shows a description of some of these errors or incorrect statements and their significance in terms of the teaching and learning of content. Most of these errors were related to inappropriate use of terminology and a lack of accuracy in mathematical language when explaining a concept. Most of these incorrect statements or inappropriate explanations were coded as lack of mathematical knowledge in teaching.

Table 4.4: Errors of expression, concepts incorrectly explained by teachers

Errors observed	**Mathematical concept involved**	**Significance**
1.	Reads $x = 3.79$ as "x is equals to three comma seventy nine"	Confusion of place value system terminology.
2.	Says the inverse of $f(x) = x^2 - 4$ is $f^{-1}(x) = \sqrt{x+4}$	Just careless in this instance. Lacking precision: $f^{-1}(x) = \pm\sqrt{x+4}, x \geq -4$
3.	Describes the transformation of the graph of $f(\theta) = \tan(\theta - 45°)$ to $h(\theta) = \tan(45° - \theta)$, as *reflection in the* $y - axis$ [writes: $h(\theta) = \tan(45° - \theta) = \tan(-(\theta - 45°))$]	Confusion on transformation of graphs. [$h(\theta) = -\tan(\theta - 45°) = -f(\theta)$, reflection in the $x - axis$]
4.	When solving quadratic equations, teacher says you cannot use quadratic formula where you can use the method of factorisation.	Misconceptions about underlying concept. Just careless in this instance.

4.3.1.3 Reflecting on observational data

A typical mathematics lesson in low-performing schools was characterised by a teacher lecturing about a concept or a topic for a short time, doing an example of an exercise on the board, and then the students work in their notebooks doing similar problems for the rest of the time. Characteristically, few (two to five) problems are set for the students (see **EXTRACT 2**). The teaching focused mainly on procedural skills and the students were engaged in cognitively low-level tasks. Teachers demonstrated knowledge of the mathematical content at the grade they were teaching (93.4% and 95.2% of teachers observed at low and high-performing schools respectively) and demonstrated varying knowledge of general pedagogical techniques at low and high-performing schools (43.6% and 72.3% respectively). However, most teachers at low-performing schools did not integrate these two domains of knowledge effectively (only 23.7%). More specifically, most teachers struggled somewhat with the issue of how best to present students with a well-sequenced series of activities that help students acquire the underlying mathematical concept. Further, some teachers at low-performing schools did not use proper mathematical language (see Table 4.4) when trying to explain concepts and they lacked the ability to effectively use models and multiple representations to illustrate abstract concepts.

4.3.2 Data from written documents

At each school, documents, as listed in the checklist marked Appendix F were examined. The following section focuses on the analysis of the examined documents.

4.3.2.1 School's vision and mission statement

All ten schools had vision and mission statements. However, only at schools 1 - 5 could one presume that the mission statement acted as a foundation for daily activities. For example, the mission statement of School 1 states:

> "School 1 is committed to work in partnership with the members of the school community to ensure that each student receives the best education possible. We will do this by:
> - meeting the needs of all stakeholders;
> - teaching the students in English so that they are all able to communicate in the language;
> - providing the necessary resources to ensure quality education;
> - working in teams and being supportive, encouraging and trustworthy;
> - preparing our students to enter the career of their choice as responsible citizens.

We hope to achieve these aims in a friendly and open atmosphere."

It was noted that at schools 1 - 5, the vision and mission statements covered the nine key areas of evaluation in the national policy on whole-school evaluation, as reflected, for example, in School 1's school improvement plan (SIP) of 2011 in Table 4.5.

Table 4.5: School 1: SIP for 2011

Areas for development	Activities for improvement	Performance indicators	Target area/ Group	Resources		Time frame	Person / group responsible
				Physical/ human	Budget		
1. Quality of teaching and learning and teacher development							
Professional develop-ment	HoDs: model good teaching practice and observe teaching Principal: observe HoDs teaching	Observed quality teaching (marked improvement in student achievement)	HoDs; teachers	HoDs and principal (observation inventory)	n.a.	10 Feb 10 Mar 10 May 9 Jun 18 Aug 19 Oct	Subject HoDs and principal
2. Leadership, management and communication							
Principal attends workshops	Sharing ideas at workshop with others	Improved leadership	Teachers and students	Staff meetings	n.a.	Week-ly	Principal
3. Governance and relationships							
SGB and SMT operational requirement	More training; duty list to be outlined	Smooth running of the school	Parents; SMT	Acts pertaining to SGB function	R 1500 p.a.	3 years	District
4. Basic functionality							
Punctuality	Be at school, in class, on time	Improved teaching and learning	The whole school staff complement	Chalk; duster; classroom	n.a.	Daily	Deputy Principal
5. Curriculum Provision and Resources							
Teachers and students	Teaching skills and methods; learning; knowledge of students, skills	Good reading and writing skills; high pass rate of students; teaching with enthusiasm	Language teachers & maths, science subjects	Textbooks; teaching aids; computers; library; science laboratory	R 20000	3 years	SGB/ SMT
6. Student achievement/attainment							

Improving academic per-formance by 30% each year	Effect fort-nightly tests in all subjects; class work and home-work given after every lesson	Improved results/ performance	Students	Textbooks; tests from internet and past exam papers	R 5000	3 years	SGB, SMT, teachers and students
7. School safety, security and discipline							
School safety and security	Cleanliness; gate security to prevent theft	Yard must be cleaned, ploughed and kept safe	Teachers and students	Security alarms, phones, keys, etc.	R 20000	3 years	SGB, SMT, teachers and students
8. School infrastructure							
Water, admin block, science lab	Addition of water tanks		Students and teachers	Community members and SGB	± R 5000	1 year	SGB and Govern-ment
9. Parents and community							
Parental involvement in children's education	Check homework and other tasks; encourage them to work hard	Parents sign their children's books; parents to consult with teachers about their child's performance	Community or parents	Chief, headman, civic organisation, SGB	R 5000	3 years	SMT/ SGB

One of the aims indicated in the national policy on whole-school evaluation is to identify aspects of effective schools and improve general understanding of the factors that create effective schools (Government Gazette, 2001:10). The core mission of schools is to improve the educational achievement of all students. Therefore, whole-school evaluation is designed to enable principals, teachers and SGB members, supervisors and support services to identify the extent to which the school is adding value to students' prior knowledge, understanding and skills (Government Gazette, 2001:11). Schools 6 - 10 also had vision and mission statements. For example, the mission statement of School 6 stated:

> "School 6 is committed to working in partnership with all stakeholders to ensure that each student receives the best education possible. We will do this by:
> - Ensuring the school has structures for monitoring and evaluating progress throughout the year and for flexibly adapting plans and practices to meet its goals for accelerating learning.
> - Ensuring school leaders consistently engage the school community and use data to set and track suitably high goals for accelerating student learning.

- Gathering and analysing information on student learning outcomes to identify trends, strengths, and areas of need at the school level.
- Aligning assessments to curriculum and analysing information on student learning outcomes to adjust instructional decisions at the team and classroom level.
- Engaging in an exchange of information with students and families regarding students' learning needs and outcomes."

How and *when* the mission statement of School 6 would be operational were missing, because the school could not provide its SIP. In light of this shortcoming, the conclusion was that, in some schools, the vision and mission statements existed but were not put to use.

4.3.2.2 Mathematics work schedules and the annual assessment programme

All schools were provided with work schedules and annual assessment programmes by the district and these documents reflected the time management and subject content distribution across the grades (see Appendix I). In schools 1 – 5, the allocated content seemed to be completed per term. For example, School 1 was doing content planned for 11 - 29 April 2011 in March 2011 (see **EXTRACT 1**, Section 4.3.1.2). When asked how T1 managed to be ahead of the work schedule and T1 said:

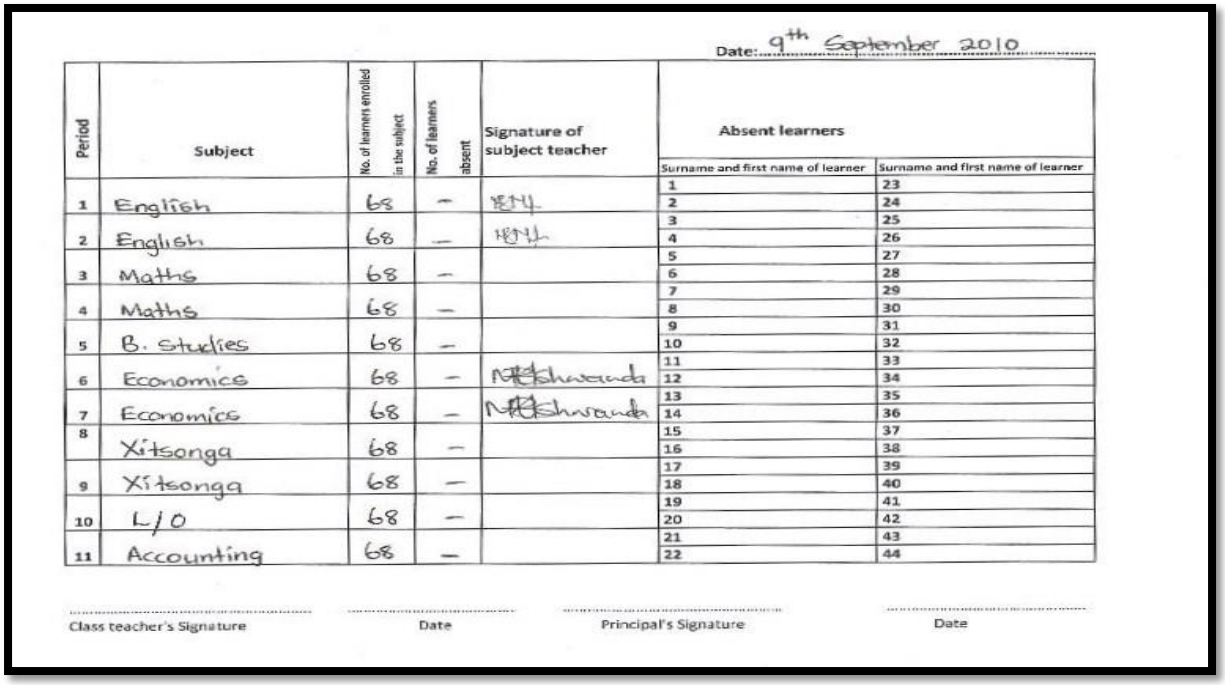
> "…We always organise extra lessons for consolidation of content taught, remedial work or coverage of the content...."

The case of School 6 (**EXTRACT 2**, Section 4.3.1.2), where the teacher was teaching Grade 11 content, led to the conclusion that little was done to support teachers in the teaching and learning of mathematics.

4.3.2.3 Lesson attendance register

The lesson attendance registers were put in place to ensure that teachers are in class teaching. All ten schools in the study had these registers and class representatives controlled the registers at the end of each lesson period. However, the control ranged from inadequate to adequate, as evidenced by a sample from the lesson attendance register of School 6, provided in Figure 4.1.

Figure 4.1: Lesson attendance register of School 6



Date: 9th September 2010

Period	Subject	No. of learners enrolled in the subject	No. of learners absent	Signature of subject teacher	Absent learners	
					Surname and first name of learner	Surname and first name of learner
1	English	68	–	[illegible]	1	23
2	English	68	–	[illegible]	2	24
3	Maths	68	–		3	25
4	Maths	68	–		4	26
5	B. Studies	68	–		5	27
6	Economics	68	–	[illegible]	6	28
7	Economics	68	–	[illegible]	7	29
8	Xitsonga	68	–		8	30
9	Xitsonga	68	–		9	31
10	L/O	68	–		10	32
11	Accounting	68	–		11	33
					12	34
					13	35
					14	36
					15	37
					16	38
					17	39
					18	40
					19	41
					20	42
					21	43
					22	44

Class teacher's Signature ..... Date ..... Principal's Signature ..... Date .....

In the lesson attendance register above, the subjects are written by the representative and teachers have to sign next to subject in the space provided. As can be seen, some teachers did not sign, which indicates that the teacher concerned did not arrive for the lesson. When P6[3] was asked how she dealt with the issue of teachers not attending their lessons, she said teachers received a verbal warning. This was also the case for indolent teachers.

4.3.2.4 Schools' mathematics departmental policies on written work and informal tests

Informal tests allow teachers to track the progress of students regularly. Informal tests are usually written each week, every fortnight, each month and so forth. While formal tests measure students' performance during the semester, informal tests provide continual snapshots of students' progress throughout the school year. By using informal tests, teachers can target students' specific problem areas, adapt instruction and intervene earlier rather than later.

All schools had satisfactory mathematics departmental policies on written work and informal tests. The following is an extract from the mathematics departmental policy on written work and informal tests for School 8:

[3]The ten principals involved in the study were coded according to the school number, i.e. from 1-10.

Table 4.6: School 8's mathematics departmental policy on written work and informal tests

Date of adoption by mathematics teachers: 06 May 2002. Signed: _____
This policy aims to increase the written tasks of students and enhance student learning.
1. Class work and homework must be given after every learning incident (lesson taught).
2. Students of all grades must write weekly informal tests.
3. All things being equal, the class work exercise books are marked before next lesson, or are marked by students exchanging exercise books in class before new lesson.
4. Students must do corrections before writing any new given work.
5. Homework must be controlled by giving answers to exercises and checking whether or not every student has done this.

Nonetheless, the common challenge was the execution of policies. As attested by the mathematics departmental policy of School 8 above, there was a lack of clearly stipulated measures to be followed by whoever failed to comply with the mathematics departmental policy. Most schools emphasised the need for all grades to write weekly mathematics informal tests and for class work and homework on a daily basis (as reflected by the mathematics departmental policy of School 8 above), but failed to stipulate the actions to be followed in cases of inconsistency. Furthermore, an analysis of the sampled mathematics class work and informal test exercise books at schools 6-10 revealed no informal tests written, but an average of 14 written exercises were completed by mid-October 2010 without dates. The conclusion was that, in some schools, the mathematics departmental policy on written work and informal tests existed but were not implemented.

4.3.2.5 Reflecting on the data from written documents

From the analysis of the written documents, the conclusion was that in schools 1 - 5, where the quality of instruction was perceived to be effective, as measured by the high pass rates in Mathematics matriculation examinations, there were written plans of action and evidence of strict adherence to them, as evidenced by the SIP of School 1 (see Section 4.3.2.1). However, it was evident from the written documents that in schools 6 - 10, it was a challenge to control students' and teachers' work. It therefore became clear, based on the performance in Mathematics matriculation examinations of schools 1 - 5, that where the principal or

mathematics HoD monitored classroom processes, as well as students' and teachers' work the process of teaching and learning would be enhanced.

4.3.3 Interview data

Interview data were collected from interviews with different respondents, as shown in Table 4.7. All interviews included open-ended questions (see Appendix C).

Table 4.7: Four groups of interviewees

Respondent	Gender		Total
	Male	Female	
Advisors	4	1	5
Principals	8	2	10
Teachers	6	4	10
Students	20	20	40
Total	38	27	65

The structure of the interviews resembled an everyday conversation and was in the form of semi-structured interviews that were conducted according to a loosely structured guide. The focus was mainly on the challenges posed by: the criteria for progression of students through the grades; the shortage of qualified mathematics teachers; class distribution and size; students' weak foundation in mathematics in previous grades or schools; organisational leadership; institutional culture; and the type of support rendered since the inception of the NCS. The goal of the interviews was to establish how schools, as institutions, integrated resources (physical resources, human resources, LTSM, etc.) to result in a particular configuration of capacity to promote high achievement levels of Grade 12 students in mathematics.

Interviews were conducted with a teacher and a sample of four students (see Section 3.2.2.2) at each of the ten schools after lesson observation. The teachers were interviewed after the lessons in their base rooms. The interviews provided for conversation with the teacher on the interpretations of what was observed in the lesson, as well as an opportunity to discuss why things were done in the way that they were. The leading question was: *Are students active participants in their own learning?* Therefore, the guiding open-ended questions for the teacher interviews included questions about how they overcame the challenges of: over-

crowded classrooms; students' weak foundation in mathematics in previous grades or schools; the alleged poor attitude towards mathematics; and the support teachers receive from the HoDs, principals, mathematics curriculum advisors and parents in the execution of their duties.

A focus group discussion with 4 students per class observed was also conducted in the teacher's base room. The leading discussion question was: *Do students elect or are they selected to do mathematics in the FET band?* Thus, the guiding open-ended questions for the student interviews included questions about how they used mathematics memoranda (mathematics marking schemes) for study purposes and whether or not they had chosen to do mathematics in the FET band.

Interviews were also held with all ten principals and five mathematics curriculum advisors before classroom observations. They were interviewed in their respective offices. The main question of focus was: *How do they support mathematics teachers in adapting to the demands of the NCS?* The guiding open-ended questions for principal and curriculum advisor interviews, therefore, included questions about how they built capacity for TLM in the areas of: the teacher's knowledge, skills and attitudes; the shortage of qualified mathematics teachers; students' weak foundation in mathematics in previous grades or schools' the lack of parental involvement in mathematics learning; the criteria for progression of students through the grades; alleged poor student attitude to mathematics; over-crowded classrooms; and problems related to the language of teaching and learning.

These interviews with teachers, students, principals and curriculum advisors were tape recorded and are presented in the form of transcripts (listed in Appendix E). The language used in all interviews was English. For principals, curriculum advisors and teachers, the average length of interviews was just under 50 minutes, with a median of 55 minutes and a range from 40 to 65 minutes. For students, the average and the median length taken for completion of interviews were both 39 minutes, with a range of 30 to 60 minutes.

All the data from the interviews were analysed using the procedure for qualitative data analysis, which involved developing units and categories, searching for patterns and then interpreting the results. The process of developing units involved isolation of general units of meaning. These units are basically broad themes and issues that recur frequently from interview transcripts. According to Denzin *et al*. (1998), expressions are classified by their

units of meaning, which can be single words or short sequence words. This is in order to attach annotations and codes or labels to them. Strauss and Corbin (1990:6) view this process as the attachment of conceptual labels on discrete happenings, events and other instances of phenomena. An example will serve to illustrate the process and this is provided below.

The following is an extract from an interview with T2, when asked about the type of professional development the teacher preferred: (see Appendix E):

> "... **...** Let the nature of the workshops be such that ***teachers showcase how they are teaching in classroom***, i.e. the organisers of the workshops should recruit experienced and ***exemplary practicing secondary school teachers to serve as presenters*** at these workshops, and allow thereafter a ***discussion of the presentation*** under the guidance of the experts from the Universities … The workshops would be relevant and meaningful to teachers and possibly ***improve their teaching practices and mathematics content knowledge***."

The transcripts were read and the informant's comments or perceptions on a particular issue were highlighted; these were then extracted as unitised data. In the example above, units are represented in bold italics. A full list of unit meanings (unitised data) is provided in Appendix G under categories.

The next step in the procedure was to categorise unitised data by grouping them in terms of phenomena discovered in the data, which are particularly relevant to the research questions. According to Strauss and Corbin (1990:74), categorisation refers to asking questions about the data and making comparisons to determine similarities and differences between each incident, event and other instances of phenomena. Similar events and incidents are labelled and grouped to form categories. In this study, extracted units of data from interviews with all groups of informants that were similar were grouped to form the categories listed in Appendix G. An extract below illustrates how 7 units of related data were grouped into one category:

Category 1: The principals should manage TLM in order to improve student performance.
• Overseeing the mathematics curriculum across the various grade-levels is lacking. • No evaluation of mathematics teachers' and students' work. • No mechanism put in place to ensure teachers are indeed teaching while in class. • No means of checking whether or not mathematics HoDs are monitoring the work of their subordinates. • A culture of TLM is lacking. • No information meetings with parents about the importance of checking and forcing their children to do mathematics homework. • Students promoted without passing mathematics in Grades 8 and 9 for fear of shrinking enrolments due to an exodus to other schools.

Lastly, a discussion on how categories were grouped to form patterns follows. According to McMillan and Schumacher (1993:495), a pattern is a relationship among categories. Links between categories were looked for and similar categories were grouped together to form patterns. An example is given below:

Pattern 1: The principal's mechanisms for exercising control before teaching, during teaching, and after completion of work planned enhance the quality of mathematics teaching and learning.
• The principals should manage mathematics teaching and learning across the various grade levels in order to improve student performance. • Extra lessons provide the potential to compensate for alleged poor preparation in previous grades or schools, and the problems arising from students being promoted through grades before they are ready. • Principals should observe a teacher teaching once every term to inform professional development. • The HoDs should lead mathematics teaching and learning through direct observation of teachers teaching and modelling good instructional practices.

Five patterns were identified, as shown in Appendix H.

Important themes emerged from the qualitative data analysis, namely the evidence from the teachers, principals, students and curriculum advisors (see Appendix E). These themes concerned how instructional capacity in TLM was constructed, organised and replenished

vis-à-vis the questions put to interviewees. Some important themes that emerged included: an adequate system of control; professional development of mathematics teachers through lesson study; instructional and organisational coherence; and the alignment of capacity building in TLM.

4.3.3.1 Adequate system of control

Control in school is the principal's means of checking whether or not the work is done (Bush & Glover, 2009). Controlling teachers' work entails observing classroom teaching and analysing LOs to elevate school-wide instructional practices and implement strategies that promote professional growth and reflection, with special focus on new teachers (Bush & Glover, 2009). However, when asked how principals build instructional capacity in TLM in the area of teachers' knowledge, skills and disposition, the following were some of the responses from principals:

> P1: "…Well … Sir, thank God I don't have staff at my school that say, 'No do not come to my class'. Everybody at my school accepts it (lesson observation) and what's goes on with it, like checking students' written work, the planned weekly work and the frequency of informal tests. So class visits is one way of discovering teachers' knowledge, skills and disposition, which may inform professional development of that teacher. However, I need to point out that I am not a qualified mathematics teacher myself, but I know of good instruction when I see it or to encourage it when I do not …"
>
> P6: "… The noble thing to do is to sometimes establish direct observation of teacher teaching, but teachers' unions said we are not allowed in classrooms. So as a result, I always make sure that teachers and students are in their classrooms and assume teaching is taking place and that the teacher has the knowledge and knows how to dish up his content."

School 1 had a class of 19 Grade 12 mathematics students in 2011. The performance pass rates at School 1 from 2008 - 2011 was 70%, 68.4%, 69.6% and 80% respectively. School 6 had inadequate classrooms and had a class of 68 Grade 12 mathematics students in 2011. The performance pass rate of School 6 for the same period was 34.9%, 22.4%, 19.1% and 24.2%. P6 was in possession of an internal control, monitoring and support tool.

Table 4.8: School 6's internal control, monitoring and support tool

Internal Control, Monitoring and Support 2010 Subject:_____ Teacher:_____ Date:_____			
	Term 1	Term 2	Term 3
Expected number of exercise books			
Number of exercise books controlled			
Expected number of exercises			
Number of exercises given to date			
Comments on students' exercise books:			
Comment on curriculum coverage:			
General comments:			

The tool shown in Table 4.8 was used in several schools to check whether or not work had been completed. However, there is a need to observe actual teaching. In fact, observation of classroom teaching should be complemented by the instrument provided in Table 4.8. With respect to the type of support teachers received from principals or HoDs, teachers had this to say:

> T2: "… I received support in the form of resource materials (like any other school), such as work schedules, annual assessment programmes and assessment tasks - but no guidance on how to teach the mathematics content. However, it would be an advantage if formal follow-up is done to observe the implementation of these resource materials in the class and help teachers adapt the implementation to their own situations …"
>
> T9: "… We are let down by our promotional policies here … there is no clear cut way of assessing whether teachers are indeed teaching when they are in class, besides depending on the test scores (which are often bad) of the controlled common assessment tasks from the district offices. When students fail mathematics at any grade, the blame game then starts: the principal often says the teachers are not teaching and the teachers say the controlled common tests are above the level of the students or the students are not preparing for the tests … as a result students are pushed to the next grade without meeting the laid down criteria. So there is no tangible support from principal or HoD …"

An adequate system of control is imperative in such circumstances, to support teachers as they develop new instructional skills in mathematics teaching and as they try to integrate a commitment to quality instruction with the demands of high-stakes testing.

4.3.3.2 Professional development of mathematics teachers through lesson study

Any development leads to change. So if we talk about professional development, what is it that we need to change? The research on change that describes and anticipates how teachers' needs change over time is helpful to guide the cycle of professional development implementation (Easton, 2009). Different strategies are more appropriate for different people, depending on where they are in the change process. In any meaningful professional development programme, teachers' learning should be sequenced over time (Loucks-Horsley *et al*., 2010:78). Hunzicker (2011:178) suggests that effective teacher professional development should be supportive, job-embedded, instructionally focused, collaborative and ongoin*g* (see Section 2.2.2.1 (b)).

Easton (2009) says emerging questions or concerns that teachers have as they are introduced to and take on new programs, practices or processes, range from questions that are more self-oriented and task-oriented, to questions that are more impact-oriented (see Section 2.2.2.1 (b)). Teacher concerns can guide the selection of strategies for professional development and provide insight into the content of the strategies in order to adequately address teachers' needs and concerns as they go through the change process (Easton, 2009). For example, if the goal of the professional development is to increase teachers' content knowledge, so that they can provide more enquiry or problem solving approaches in mathematics classes, the designer might choose to first offer teachers an immersion experience in mathematics and thereafter workshops that help raise teachers' awareness of what new teaching practices look (and feel) like in action. After they practice new methods in their classrooms, they need opportunities to meet with other teachers to discuss what is working and how to make refinements (Loucks-Horsley *et al*., 2010: 163).

What type of workshops do we have to create to bring about change in TLM? Re-conceptualising professional development to align with the needs of adult learners allows us to shift our efforts from a 'one shot, sit and get' model to one where teacher learning becomes part of the daily routine (Hunzicker, 2010:177). Typical comments from teachers regarding the type of workshops that best suit them were:

> T1: "… Mathematics is a practical subject. So listening to a presenter from one of these universities will not improve how we should teach the subject … In my view, we should workshop ourselves … by which I mean, to the topics that are said to be problematic, there are classroom teachers who have the knowledge of these topics and I would like them to teach the topic while other teachers observe

and learn and then afterwards open a discussion, with the help of the university presenters … that way teachers will learn far much better."

T2: "… Let the nature of the workshops be such that teachers showcase how they are teaching in classrooms, i.e. the organisers of the workshops should recruit experienced and exemplary practising secondary school teachers to serve as presenters at these workshops; and allow thereafter a discussion of the presentation under the guidance of the mathematics education experts from the universities … The workshops would be relevant and meaningful to teachers and possibly improve their teaching practices and maths content knowledge."

T7: "… All other things being equal, if the workshops that we have attended so far were effective, we could have witnessed a marked increase in student achievement in maths … So if the workshops cannot support our ongoing growth and development, then it relinquishes significant opportunities to influence teacher practice and student achievement. So they (the DoE) should change their workshop models and give teachers a chance to workshop themselves under their watchful eye …"

These comments from teachers clearly indicate that the model of professional development employed by the DoE emphasises short-term workshops with little formal follow up. The activities seem intended to enhance teachers' knowledge of the direction of the reforms and of the subject area, but do not significantly help them develop the pedagogical skills needed for major changes in practice. Instead, teachers treat these workshops as peripheral ornaments, rather than opportunities for significant learning and change. Teachers' task and impact-oriented questions can be addressed through opportunities for them to examine student work or to conduct action research into their own questions about student learning. During these latter stages of learning, teachers are often engaged in examining their experiences in their classroom, assessing the impact of the changes they have made on their students and thinking about ways to improve (Loucks-Horsley *et al*., 2010).

At this point in their learning, teachers also reflect on the practice of others, relating these to their own and generating ideas for improvement (Loucks-Horsley *et al*., 2010). Therefore, alternative forms of professional development, such as lesson study (see Section 2.2.2.1 (b)), are essential to help teachers develop their content and pedagogical knowledge and to influence their perceptions about the desirability of new approaches to student learning. That is to say, a situation can be created wherein teachers realise that there is something wrong with their current teaching practices. The essence of lesson study is that teachers plan lessons collaboratively and the lesson is then taught by one of the teachers while being observed by the other teachers. Afterwards, the teachers discuss the lesson (see Section 2.2.2.1 (b)). This approach allows teachers to realise that there is something wrong with their current teaching

practices and may inspire them in the sense that it encourages them to succeed in content and methods that initially seemed foreign to them.

4.3.3.3 Instructional and organisational coherence

As instructional leaders, principals give greater attention to working with teachers in coordinating the school's instructional programme, solving instructional problems collaboratively, helping teachers secure resources and creating opportunities for in-service and staff development (Bush & Glover, 2009:37). The basic issue is one of determining at which point, in schools, leadership should be exercised in order to ensure both their existence and organisational survival (requiring social control) and their organisational progress (requiring individual or group development) (Bush & Glover, 2009:37). In other words, the basic questions to be asked in instructional and organisational coherence are:

1. To what extent does the school:
    - develop teacher pedagogy from a coherent set of beliefs about how students learn and ensure that it is aligned to the curriculum, engaging and differentiated so as to enable all students to produce meaningful work?
    - make strategic organisational decisions to support the school's instructional goals and meet student learning needs?

2. What is the nature and degree of individual or group development needed for the school to progress? (Bush & Glover, 2009)

Typical teachers' comments regarding instructional and organisational coherence were:

> T8: "… Principals should avoid enrolling so many students, where there are few classrooms, resulting in classes being over-crowded, for their own selfish ends … a notch in their salaries."
>
> T9: "… Work schedules for Grade 10 and 11 can never be finished within the stipulated time-frame without extra teaching during weekends or holidays. On the other hand, the SMT are reluctant to pay for such extra teaching, except for the Grade 12s. There is too much or unparalleled focus on Grade 12, as compared to Grade 8, 9, 10 and 11, because no one knows or bothers to know what is taking place in those grades. Therefore the obvious thing is students move to Grade 12 with uncompleted content of previous grades. As a result, the pace at which we teach these students at Grade 12 in order to bridge the gap created, does not take on board the slow students - hence low achievement levels of students in mathematics matriculation examination …"

In the opinion of Stronge (2007), most teachers view teaching and learning as a reciprocal process and an equal partnership, in which teachers, the school management team and students all shape the environment and support the learning endeavour through their thoughts and behaviours. Each school has its own social structure and tends to organise instruction according to prevailing local conditions. Thus, the core purpose of a principal is to provide leadership and management in all areas of the school (e.g. student distribution in class; ensuring that students who enter the next grade but are below proficiency receive mathematics skills support; considering student work and teacher recommendations when selecting students to do mathematics, etc.) to enable the creation and support of conditions under which quality teaching and learning takes place (Bush & Glover, 2009).

Focusing on Grade 12 at the expense of other grades impacts negatively on the achievement levels of students, because mathematics is a 12-year syllabus. Mathematics is significantly different from other subjects, since each topic requires prior knowledge and the entire syllabus is integrated and dependent on sound algebraic skills and a feel for numbers. Apart from that, the use of unqualified teachers to teach mathematics at Grades 8 and 9 is much more popular in low-performing schools than in high-performing schools. The principals were aware of this shortcoming in their deployment of teachers, as evidenced by their comments, e.g.:

> P6: "… I have a problem here … Well, due to shortage of mathematics teachers, I turned an English teacher into mathematics teacher as a last resort, even though we restrict him to teaching Grade 8 and 9 only … It's a sad situation but what else can we do …?"
>
> P7: "… No one would advocate for non-qualified mathematics teachers to teach mathematics. However, I cannot leave students without a teacher to attend to them. When teachers leave, mostly through redeployments as a result of dwindling enrolment or for whatever reason, I play the 'substitution game' … I mean I just assign any teacher with fewer periods to help teach mathematics."

This type of organisational decision does not support any school's instructional goals and neither does it support students' learning needs and should be avoided at all costs.

4.3.3.4 Alignment of capacity building in TLM

Due to accountability pressures, there is a tendency in schools to focus on preparation for examinations, which usually leads to an emphasis on covering content material in the syllabus in Grade 12. In other words, teachers opt to provide students with the necessary

skills by working out problems similar to those that have occurred in past examination papers (as is the case in **EXTRACT 2**, Section 4.3.1.2). Therefore, the modes of pedagogy in the classroom rely heavily on the transmission of knowledge model. In low-performing schools, the use of memoranda or the chalk-and-talk method was very common and there was little inclination towards reform-oriented pedagogical techniques, such as cooperative learning environments wherein students are encouraged to engage in group work, discussion, reasoning and questioning, and to develop their communication skills (as can be seen in **EXTRACTS 1** (Section 4.3.1.2)). Furthermore, teachers complained about the over-emphasis on Grade 12 when it comes to remedial intervention strategies. One teacher lamented:

> T9: "… Work schedules for Grade 10 and 11 can never be finished within the stipulated time-frame without extra teaching during weekends or holidays. On the other hand, the SMT are reluctant to pay for such extra teaching, except for the Grade 12. There is too much or unparalleled focus on Grade 12, as compared to Grade 8, 9, 10 and 11, because no one knows or bothers to know what is taking place in those grades. Therefore the obvious thing is students move to Grade 12 with uncompleted content of previous grades. As a result, the pace at which we teach these students in Grade 12, in order to bridge the gap created, does not take on board the slow students - hence low achievement levels of students in mathematics matriculation examination …"

Therefore, our remedial interventions should cater for all grade levels, rather than for Grade 12 alone. This is what the principal of a high-performing school expressed when asked how he built capacity for TLM in light of students' weak foundation in mathematics in previous grades or schools:

> P3: "… We organise extra lessons, specifically for teaching Grade 8 and 9 basics in mathematics and Grade 10 to 12 content coverage, because the content is concentrated, so that it's not practical to accomplish it within the stipulated time-frame …"

Another worrying factor is the unproductive use of mathematics memoranda by teachers and students, as reflected by teachers' and students' comments regarding the benefits and drawbacks of using a mathematics memorandum, e.g.:

> S20[4]: "… The mathematics memorandum is not doing any good to us as students, because we tend to memorise the workings of questions in the memorandum, but it's not all … During examination time, it becomes difficult to attempt the questions …"

[4] The forty students involved in the study were coded according to the school and given a number from 1-40.

S33: "… Our teacher always makes sure he writes the mathematics memoranda of all written tests and examinations on the board, as corrections, so that we can copy for our own revision … So, you know what, we normally memorise the memoranda when preparing for the examinations …"

T2: "… The advantage of the mathematics memorandum, as a learning and teaching support material, would be the use by students to refer to it after they have worked out the questions from the past examination papers … However, having the memorandum would cease to be an advantage if students simply study or memorise how a certain question was worked out. In the same vein, as a teacher, one cannot teach copying the workings from a memorandum … Both teachers and students need to develop a skill of solving problems, not a skill of following what someone has already done to solve the problem …"

T9: "… We have a serious challenge at this school … our students have a tendency of memorising the memoranda of previously written mathematics matriculation examination papers in preparation for their final mathematics matriculation examination … this has contributed negatively to their performance in mathematics …"

Since instruction occurs in interactions between teachers and students in relation to educational materials, capacity resides in these interactions. Any of the three elements (teacher, students and materials) can influence instructional capacity. Improved capacity depends on affecting the ways in which teachers, students and materials understand, make use of and influence one another. Therefore, whatever resources students bring (such as experience, prior knowledge, and habits of mind) to instruction, influence how they apprehend, interpret, and respond to materials and teachers. So capacity may be diminished when students bring fewer resources to the interaction. It follows that to improve capacity would be to affect how teachers, students and materials understand, make use of, and influence one another. Students should avoid checking solutions to mathematics problems in memoranda before they work out the questions themselves. One student acknowledged this when asked how a student can use the mathematics memorandum during preparation for the mathematics examinations, i.e.:

S3: "… I simply copy the answers (not the process) and fight hard to arrive at those answers … In fact, it is like in our basic textbook (classroom mathematics, by Laridon, Essack, Kitto, Pike, Sasman, Sigabi, & Tebeila, *2006*), and it has answers only … So our task as students is to find out how the answers were arrived at …"

The teacher's role in using students and materials to produce instruction and learning is therefore distinct in any conception of instructional capacity, for materials do not use students or teachers, though they can be adopted for better or worse use by teachers and students. It is

true that students do use teachers and materials - and that a part of the instruction process is teaching students to use them better. So, in essence, teachers should discourage students from studying the mathematics memoranda.

4.3.3.5 Reflecting on the interview data

From the analysis of interview data, it is posited that the contributions that mathematics curriculum advisors, principals of schools and students make in TLM influence (positively or negatively) the teacher's approach to student learning. Where the principal or curriculum advisor is unaware of the challenges teachers encounter in the execution of their duties, he/she can hardly create opportunities for meaningful in-service and staff development. It emerged in the data that teachers are subjected to professional development that does not respond to their classroom situations.

Teachers find it a challenge to teach a very large class, with students who are pushed to the next grade without passing the previous grade. In respond to this challenge, it emerged that the modes of pedagogy teachers then employ in the classroom rely heavily on the transmission of knowledge model, as they opt to provide students with the necessary skills by working out problems similar to those that have appeared in past examination papers.

It also emerged that, even though the mathematics curriculum advisors always make sure work schedules and annual assessment programmes are in schools and on time, no formal follow-up is done to observe the implementation of these resource materials and render support where it is needed.

There are also situations in some schools where students' work and teacher recommendations, when selecting students to do mathematics at FET band level, are not taken into consideration. This in turn retards any effort to create and support conditions under which quality teaching and learning takes place. Teachers then find themselves working with students who are not receptive to grade level content and who then resort to memorising the mathematics memoranda in preparation for high stakes examinations. How teachers then identify, mobilise and activate resources for mathematics instruction hinges heavily on the support (contributions) they receive from principals, curriculum advisors and students. This assertion is grounded in the realisation from the data that some of the challenges teachers experience in TLM emanate from the lack of support from principals and curriculum advisors, coupled with students' weak foundation in earlier grades.

4.4 SUMMARY OF THE CHAPTER

Data were collected in order to establish: the level of instructional capacity of mathematics teachers; the challenges teachers experience in the process of developing such capacity; and the contributions students, principals and mathematics curriculum advisors render to teachers in an effort to support conditions under which TLM takes place. It is on this basis that data were collected using semi-structured interviews, lesson observations and document analysis.

An analysis of the documents, lesson observations and interview respondents' views highlighted factors that had a positive or negative impact on students' performance in mathematics. Data have shown that teachers demonstrate knowledge of mathematical content at the grade level they are teaching and also demonstrate knowledge of general pedagogical techniques. However, most teachers do not integrate these two domains of knowledge effectively. More specifically, most teachers do not present the students with a well-sequenced series of activities that help students acquire the underlying mathematical concept. In fact, the modes of pedagogy they employ in the classroom rely heavily on the transmission of knowledge model.

It was also evident from the data that, even though there were written plans of action in schools, together with mathematics work schedules and annual assessment programmes, control of these ranged from inadequate to adequate, and it was a challenge in some schools to control students and teachers' work. So how schools, as institutions, integrate resources (be they physical resources, human resources or teaching and learning support materials, etc.) to result in a particular configuration of capacity to promote high achievement levels of Grade 12 students in mathematics, remains the biggest challenge in schools. To this end, a discussion of the research findings derived from the data will be presented in the next chapter.

CHAPTER 5

DISCUSSION AND IMPLICATIONS OF RESEARCH FINDINGS

5.1 INTRODUCTION

The study on how the NCS constructs, organises and replenishes instructional capacity in TLM in a secondary school, focuses on tapping some of the contextual challenges and successes in ten schools in the MWC in the Vhembe District of Limpopo Province. However, it is important to note that the new curriculum (CAPS), introduced in 2011, was a result of: reorganisation of curriculum and assessment, characterised by the subtraction and addition of specific unit content; and the reduction or addition of a number of assessment tasks within a school calendar year (e.g. probability in the FET band will no longer be part of an optional paper (Paper 3)). Hence the findings of this study remain valid, even for future curricula, because the focus is on instructional capacity in TLM.

In the presentation of instructional practices in the previous chapter, focus was on some of the key features of the description of instructional capacity in TLM at low-performing schools and high-performing schools. The discussion illustrated what appear to be disparate strengths in the capacity of high- and low-performing schools to teach mathematics. Based on an analysis of the data collected from observations, interviews and written documents, the findings detailed below were obtained.

5.2 DISCUSSION OF RESEARCH FINDINGS

5.2.1 How do mathematics teachers identify, mobilise and activate resources for mathematics instruction?

Classroom observations revealed that in some schools teachers used the memorandum (see **EXTRACT 2**, Section 4.3.1.2) to present content to students. The practice has been named the memorandum-chalk-and-talk method of imparting knowledge. If instruction requires all three components (the teacher, students and materials), then according to Cohen and Ball (1999:3):

> … instructional capacity – the capacity to produce worthwhile learning – must also be a function of the interactions among these three elements, not the sole province of any single one, such as teachers' knowledge and skill or the curriculum.

By focusing on the interactions among the three components of an instructional unit, Cohen and Ball (1999:3) bring to the fore an important dimension of instructional capacity, viz. the social dimension. In other words, the capacity to deliver quality instruction depends, not only on the individual teacher's intellectual and personal resources, but also on his or her interaction with, among others, specific groups of students and materials developed by others. The teachers' role in *using* students and materials to produce instruction and learning is therefore distinct in any conception of instructional capacity, for materials do not *use* students or teachers, though they can be adapted for better or worse use by teachers and students, as attested below by students explaining how teachers help them prepare for examinations:

S21: "… They give us all the memoranda available…"

It is true that students do use teachers and materials and that a part of the instruction process is teaching students to use them better. When queried further how the students then use the memoranda distributed for study, one student said:

S29: "…you know what, we normally memorise the memoranda when preparing for the examinations."

One result of this practice has been that, in an examination situation, students find it difficult to attempt questions. One student lamented:

S23: "… The memorandum is not doing any good to us as students, because we tend to memorise the workings of questions in the memorandum, but it's not all … During examination time it becomes difficult to attempt the questions …"

When asked why his lesson was teacher-dominated, the teacher in EXTRACT 2 said:

T6: "…actually we as teachers normally try to encourage active participation from students, since it is something that has been emphasised by our Department … But, somehow, I think because of the time factor, we teachers end up solving the problems for our students in order to cover all the content …"

This assertion simply indicates that the teacher was unable to maintain the tension between simultaneously covering the content and attending to student understanding. There is considerable evidence that teachers vary in their ability to notice, interpret and adapt to differences among students. Important teacher resources in this connection include: their conceptions of knowledge, understanding of content and flexibility of understanding; acquaintance with students' knowledge and ability to relate to, interact with, and learn about students; and their repertoire of means to represent and extend knowledge and to establish

classroom environments (Heck, 2007). All these resources mediate how teachers shape instruction. Consequently, teachers' opportunities to develop and extend their knowledge and capabilities can affect instruction considerably by affecting how well teachers make use of students and materials (Heck, 2007).

Apart from that, the resources that students bring influence what teachers can accomplish. Students bring experience, prior knowledge and habit of mind, and these influence how they apprehend, interpret and respond to materials and teachers (Heck, 2007). Teachers lamented teaching very large class sizes with students who are progressed to the next grade without passing the previous grade, as teachers proclaimed:

> T8: "… Principals should avoid enrolling so many students where there are few classrooms, resulting in classes being over-crowded…"
>
> T9: "… We are let down by our promotional policies here… students are pushed to the next grade without meeting the laid down criteria…"

Under such conditions, teachers' repertoire of means to represent and extend knowledge and to establish the classroom environment is greatly affected; teachers then opt to provide students with the necessary skills by working out problems similar to those that have appeared in past examination papers. In contrast, the characteristics of facilitative teachers and the strategies to enhance learning and increase independence in students show remarkable similarities to constructivism (see Section 2.3.1.2 and 2.3.1.3). Watkins (2005:135) emphasises the facilitative teacher's awareness of students' "capacities, needs and past experience" and the ability to use this information to "create a learning situation in which students can meet their needs or solve a problem in an autonomous and independent way" (see **EXTRACT 1**, Section 4.3.1.2). With this kind of teaching practice, students are treated differently from the way they are treated in the memorandum-chalk-and-talk method, as: they are "encouraged to increasingly take responsibility for their own learning"; they are allowed to "provide much of the input for the learning which occurs through their insights and experiences"; and they "are encouraged to consider that the most valuable evaluation is self-evaluation" and that learning needs to focus on factors that contribute to solving significant problems or achieving significant results (Mitchell, 2010:4).

These kinds of ideas about students and their abilities are likely to mediate the implementation of an intervention that aims to improve student performance in mathematics. However, efforts to make change through materials have frequently proved disappointing,

because the developers have failed to consider either the teacher's or student's role in learning to use the materials (Bush & Glover, 2009), for example, the inappropriate use of memoranda by both teachers and students.

When asked how curriculum advisors ascertain the actual teaching of the content in the work schedules they send to schools, one advisor had this to say:

> A2: "… We trust that the principal, the HoDs and the teachers work hand in hand to complete the schedules in time …"

The curriculum advisors took comfort in delivering materials and sat back and assumed teachers can use them. The observed teachers demonstrated knowledge of the mathematical content at the grade they were teaching and teachers from high-performing schools demonstrated knowledge of general pedagogical techniques. However, 76.3% of teachers from the low-performing schools did not integrate these two domains of knowledge (mathematical and pedagogical) effectively (see Table 4.3). More specifically, most teachers struggled somewhat with the issue of how best to present students with a well-sequenced series of activities that help students acquire the underlying mathematical concept. Further, many of them do not use proper mathematical language when trying to explain the concepts (see Table 4.4) and they lack the ability to effectively use models and multiple representations to illustrate abstract concepts.

Given what have been alluded to above, how mathematics teachers identify, mobilise and organise resources for mathematics instruction leaves a lot to be desired, although teachers from high-performing schools appear to be way ahead of those from low-performing schools in this regard.

5.2.2 What is the level of instructional capacity of mathematics teachers?

The introduction of OBE was an unprecedented curriculum reform in the history of South Africa. There was a huge gap at the time between the aims of OBE and what the majority of teachers had been trained for (see Section 2.2.2.1). It was a challenge for many South African teachers who had inadequate knowledge, skills and competence and who relied on teacher talk and rote memory as the predominant mode of teaching and learning (Jansen & Christie, 1999). Because OBE differs from previous practice, rather than mount a series of professional development programmes, that engages teachers in learning activities that are supportive, job-embedded, instructionally focused, collaborative, and ongoing, the DoE

introduced a "cascade" model through which teachers were trained and in turn had to pass their knowledge on to their colleagues (see Section 2.2.2.1). How effective was/is this cascade model?

During the interviews and with reference to the effectiveness of workshops, teachers vehemently disapproved the manner in which the workshops were conducted:

> T2: "… It is unfortunate that teachers are summoned for a workshop only to be given materials or should I call them individual study materials … which are first read to us by the presenters … then why calling a workshop instead of just sending the materials to schools and spare teachers from wasting valuable teaching time for nothing."
>
> T7: "… All other things being equal, if these workshops were effective we could have witnessed a marked increase in student achievement in maths … So if the workshops cannot support our ongoing growth and development then it relinquishes significant opportunities to influence teacher practice and student achievement. So they (the DoE) should change their workshop models and give teachers a chance to workshop themselves under their watchful eye …"

Tobe (2009) found students at all levels benefited equally from having effective teachers although lower-achieving students were more adversely affected by ineffective teachers. The logic is that if teacher quality improves through certification standards and professional development, student achievement will follow (Tobe, 2009).

It is interesting to note that if the professional development workshops are characterised by the presenter-talk method, teachers will not see any reason for embarking on a different approach in their classroom besides the teacher-talk method, because that is the method advanced at workshops. This mode of teaching was evident in the observed lessons where the modes of pedagogy employed in classroom relied heavily on the transmission of knowledge model. In the opinion of Lee (2007), individual teacher differences will always be present, but effective forms of professional development should reduce these differences to the point that every teacher ensures that no child is left behind. Hunzicker (2011:178) suggests that effective teacher professional development should consider the needs, concerns, and interests of individual teachers along with those of the school, be relevant and authentic (Job-embedded), involve the study and application of content and pedagogy with emphasis on student LOs, engage teachers in both active and interactive learning and be a combination of contact hours, duration and coherence. Therefore, teacher professional development becomes relevant when it connects to teachers' daily responsibilities and becomes authentic when it is

seamlessly integrated into each school day, engaging teachers in activities such as coaching, mentoring and study groups (Hunzicker, 2011).

Drawing from the interviews with teachers, the teachers want workshops to be presented by "one of their own", as some teachers suggested**:**

> T1: "… Mathematics is a practical subject. So listening to a presenter from one of these universities will not improve how we should teach the subject … In my view, we should workshop ourselves … by which I mean, to the topic that are said to be problematic, there are classroom teachers who have the knowledge of these topics and I would like them to teach the topic while other teachers observe and learn and then open a discussion with the help of the university presenters … that way teachers will learn far much better."
>
> T4: "… These teacher professional development workshops are disconnected from classroom practices … Seeing someone teaching, as if students are there, provides us with richer knowledge and more informed strategies for improving teaching practices …"

These suggestions clearly indicate the need for effective teacher professional development rather than the 'one shot', 'sit and get' presentation-style workshops which are less effective because much of the information gained is not likely to be applied once teachers return to their daily routine (Hunzicker, 2010). Professional development was found to improve teachers effectiveness, when focused on teaching specific parts of the curriculum, occurred over time, engaged teachers in a professional community of practice, offered relevant expertise, focused on methods to improve student outcome and when school authorities support teachers' opportunities to learn and process new information (Timperley, Wilson, Barrar & Fung, 2007).

In the light of the continued faith in professional development and its relationship to the task of enhancing the culture of TLM, it is important to keep in mind that professional learning occurs within people who live and work in unique contexts that can either thwart or support professional development (Blank, De las Alas, & Smith, 2008). Therefore, a school-based professional development, teacher facilitated (with support materials) in which all teachers participate, would be productive. This is likely to be more effective because it often is led by current classroom teachers, whom other teachers trust as a source for meaningful guidance on improving teaching (Blank *et al*., 2008).

Therefore teacher concerns (such as teaching large class sizes, student pushed to next grade not ready, workshops divorced from classroom situations, etc.) and shortcomings (as

reflected in the observational data, Table 4.3 and 4.4) can guide the selection of strategies for professional development and provide insight into the content of the strategies in order to adequately address teachers' needs and concerns as they go through the change process. For example, if the goal of the professional development is to increase teachers' content knowledge so they can provide more enquiry or problem solving approaches in mathematics classes, the designer might choose to first offer teachers' an immersion experience in mathematics and then workshops that help raise teachers' awareness of what new teaching practices look (and feel) like in action (Loucks-Horsley *et al*., 2010: 163). As they practice new moves in their classrooms, they need opportunities to meet with other teachers to discuss what is working and how to make refinements (Loucks-Horsley *et al*., 2010: 163).

Teacher professional development such as lesson study (see Section 2.2.2.1 (b)), whose salient feature is that teachers are collaboratively engaged in action research in order to improve the quality of instruction (Ono, 2008*),* would probably suit the concerns and shortcomings as revealed by the interview and observational data respectively.

On the basis of the teachers' concerns and shortcomings reflected in the data, it is posited that professional development activities that centre on improving the mathematics knowledge in teaching (which is demonstrated in the class by how well a teacher uses mathematical and pedagogical knowledge to help learners learn mathematics) of teachers would go a long way to improving the level of instructional capacity of mathematics teachers.

5.2.3 What other challenges do mathematics teachers experience in the process of developing instructional capacity?

There are several factors that can enhance or inhibit students' learning, with teacher effectiveness being the most important factor (Looney, 2011). Teachers appear to be the single most important school-based input that affects student achievement (Motoko, Letendre & Scribner, 2007). Nye, Konstantopoulos and Hedges (2004) showed that students from low-income families may benefit the most from learning with very effective teachers. If instructional capacity is a property of the interaction of teacher, students and materials, here we can see teachers' unique position in the construction of instructional capacity (Heck, 2007). Teachers' knowledge, experience and skills affect the interaction of students and materials in ways that neither students nor materials can. This is because: teachers mediate instruction; their interpretation of educational materials affects curriculum potential and use;

and their understanding of students affects opportunities for students to learn (Mercer & Hodgkinson, 2008). The question is then: How does one teach a group of 70 students a subject that one has hardly mastered oneself, under trying conditions, with no learning media and when not using their mother tongue?

Sanders and Rivers (1996) found that the effects of poor quality teachers on students were long lasting and that even when they learn under high quality teachers latter, gaps still exists in students' achievement. The use of unqualified mathematics teachers by some principals may be a mechanism adopted to survive in the era of a shortage of mathematics teachers. This can be seen in the principals' responses regarding the use of unqualified mathematics teachers to teach mathematics, e.g.**:**

P6: "… I have a problem here … Well, due to shortage of mathematics teachers, I turned an English teacher to mathematics teacher as a last resort, even though we restrict him to teach Grade 8 and 9 only … It's a sad situation but what else can we do?"

P7: "… No one would advocate for non-qualified mathematics teachers to teach mathematics. However, I cannot leave students without a teacher to attend to them. When teachers leave, mostly through redeployments as a result of dwindling enrolment or for whatever reason, I play the 'substitution game'… I mean, I just assign any teacher with fewer periods to help teach mathematics."

P8: "… Teachers who are not knowledgeable in mathematics weaken the foundation in earlier grades. I have learnt to live with it but it's killing our results at Grade 12."

It follows from these statements that the idea that schools should coordinate instruction internally – to ensure that students' opportunities to learn are coherent within and across grade levels – seems unusual in practice at schools; few schools seem to have the means of establishing or sustaining such coordination. However, the importance of leadership in shaping the school's ability to offer quality instruction cannot be over-emphasised. The dominant strand of instructional leadership studies starts from the premise that principals constitute one of the key drivers of what occurs in each classroom in the school. Danita (2006), for example, observes that research on school effectiveness concluded that strong administrative or principal leadership was one of the "within-school" factors that made a difference in student achievement. Furthermore, Dhlamini (2008) found that principals can learn a great deal about: how and under what conditions new instructional methods work in the classroom; how to support teachers as they acquire or develop new instructional skills;

and how to integrate a commitment to quality instruction within the demands of high-stakes testing.

Mathematics has a 12-year syllabus and the entire syllabus is integrated and dependent, among others, on sound algebraic skills and a feel for numbers. Given a weak foundation in previous grades, it follows that teachers will find it difficult to employ dialogic teaching, which is seen as being: collective, supportive and reciprocal, through the sharing of ideas and alternative viewpoints; and cumulative, in group-based and whole-class situations (Mercer & Hodgkinson, 2008). Observational data bears testimony to this (see EXTRACT 2, Section 4.3.1.2), as some teachers employed modes of pedagogy in the classroom that relied on the transmission of knowledge model. Therefore we cannot afford to ignore Grades 1 to 11 and hope for high student performance in Grade 12, because students' past experiences and capacities in mathematics can be used by teachers to create a learning situation in which students can meet their needs or solve a problem in an autonomous and independent way. Hence there is a need for the lower grades to have qualified mathematics teachers in order to attain high achievement levels in mathematics in Grade 12.

5.2.4 What contribution, if any, do students, principals of schools and mathematics curriculum advisors make to the development of instructional capacity?

In schools, few principals enact their role of an instructional leader; though many now claim such a role, in practice few know how to do such work and most leave such matters to the individual teacher's discretion (Bush *et al*., 2009). Through observation and interviews, various factors that hampered effective TLM were identified, for example: over-crowded mathematics classrooms; the deployment of non-qualified mathematics teachers to teach mathematics; overemphasising Grade 12 at the expense of other grades; the emerging use of the memorandum-chalk-and-talk method; and a lack of support and guidance for students when selecting Mathematics or Mathematical Literacy. Students who progress to the next grade (or arrive at a secondary school) with a history of constant failure in mathematics usually withdraw from further efforts to learn and succeed in mathematics (Even & Kvatinsky, 2009) and have nothing to contribute in the construction of instructional capacity.

Sanders and Rivers (1996) found that the effects of poor quality teachers on students were long-lasting and that even when they later learn under high-quality teachers, gaps still exists

in students' achievement. For example, when a student was asked whether or not she elected to do mathematics, she responded:

> S10: "… In primary I never put effort to pass mathematics … and apart, I simply switched off that subject in Grade 8 and 9... I only realised in Grade 10 that for one to be an accountant, Mathematics is a requirement…but I cannot cope now ..."

Thus, the core purpose of a principal is to provide leadership and management in a school to enable the creation and support of conditions under which quality teaching and learning takes place (Bush, 2003). Bush and Glover (2009:19) point out that even a combination of well-planned objectives, strong organisation, capable direction and motivation has little probability of success unless an "adequate system of control" is in place. Control in a school is the "principal's means of checking whether the work is done". The principal, as instructional leader, therefore, should do everything in his/her capacity to deal promptly with challenges hindering proper TLM, particularly (and most importantly) in terms of controlling teachers' work.

Bush and Glover (2009) (referring to the South African context) claim that a principal who focuses strongly on managing teaching and learning would, among other things: ensure that lessons take place; evaluate student performance through scrutiny of examination results and internal assessments; monitor the work of HoDs through scrutiny of their work plans and portfolios; ensure that HoDs monitor the work of teachers within their learning areas; arrange class visits (of a clinical nature) followed up by feedback to teachers; etc. During the interviews, various teachers blamed the principals for not supporting them as mathematics teachers, e.g.:

> T9: "… Our mathematics pass rates are not pleasing here … We are let down by our promotional policies here … there is no clear-cut way of assessing whether teachers are indeed teaching when they are in class, besides depending on the scores (which are often bad) of the controlled common tests from the district offices. As a result, the principal often blames the teachers for not teaching and the teachers say the controlled common tests are above the level of the students or say the students are not preparing for the tests … So ultimately students are pushed to the next grade without meeting the laid down criteria. So there is no tangible support from principal or HoD …"

The organisational culture of a school is defined by the nature and content of the professional community, the collaboration among staff members, collective and shared goals for TLM and opportunities for students and staff to exert an influence on the teaching and learning at their

school (Newman *et al.*, 2000). It was disturbing to note that the main focus of influential unions, such as South African Democratic Teachers' Union (SADTU), is to empower teachers to do things their own way - hence the authority and influence of the principal is marginalised. This assertion is corroborated by principals' comments regarding how they establish teachers' knowledge, skills and disposition in mathematics, e.g.:

> P4: "… It's a question of faith … Teachers' unions made our role as instructional leaders a bit complicated … I can't observe lessons … neither my mathematics HoD. So we rely on test scores … which are at most bad."
>
> P5: "… It's not easy to ascertain what transpires inside the classroom, because of teacher denial. I simply believe they (teachers) have the knowledge and skill to implement the reform efforts … and associate low test scores with the belief that mathematics is a difficult subject."
>
> P6: "… The noble thing to do is to sometimes establish direct observation of teachers teaching, but teachers' unions said we are not allowed in classrooms. So as a result, I always make sure that teachers and students are in their classrooms and assume teaching is taking place and that the teacher has the knowledge and knows how to dish up the content."

The substitution of a professional approach to teaching with the unionist approach contributes to the demise of the culture of teaching and learning in mathematics. A curriculum advisor, when asked how he helps teachers adapt their teaching practices to the demands of the NCS, had this to say:

> A1: "… To help teachers adapt to the demands of NCS, we have common work schedules, assessment plans, tests, assignments, investigation and projects given to every school within the circuit … This is done to ensure uniformity in teaching and compliance with the learning outcomes and assessment standards in mathematics … It does not mean we do not trust teachers, but we are saying the NCS has new content and assessment styles that the current crop of teachers never did during their training …"

Of course, change in materials (content) has the potential to change the relations of teacher, students and materials - and hence to affect instructional capacity. But change in teachers has a unique potential, because teachers mediate all relationships within instruction (Loucks-Horsley *et al.*, 2010). So the teacher's interpretation of educational materials produced by others (such as work schedules, memoranda, etc.) affects the potential and use of the curriculum. Hence, if instructional capacity is a property of interactions among teacher, students and materials, then interventions are likely to be more effective if they target more interactions among those three elements of instruction, rather than focusing on one element in

isolation from others. Interventions that focus, not only on aspects of particular elements, but also on their relations, are more likely to improve capacity (Loucks-Horsley *et al*., 2010: 163). So availing resource materials, without formal follow-up to monitor implementation, will not help construct quality instruction.

It follows from this analysis that any given element of instruction shapes instructional capacity by the way it interacts with and influences the other elements. One of the curriculum advisors was asked how they ascertain implementation of the resources they send to schools and the advisor had this to say:

> A2: "… We ascertain by the assignments, end of term and year tests given to all our schools and have trust that the principal, the HoDs and the teachers work hand-in-hand to complete the schedules in time … But sometimes, if the HoDs or principals are not involved, it is not easy to ascertain …"

Ideally, curriculum advisors delegate the task of monitoring what goes on in classrooms to principals and HoDs. Bush and Glover (2009) (referring to the South Africa context) claim that a principal who is focused strongly on managing teaching and learning, would arrange a programme of class visits followed by feedback to teachers, thereby supporting them in the process of constructing instructional capacity in TLM. This would help both principals and HoDs to identify instructional problems, determine the cause of problems, and jointly work towards finding a solution. Nothing can compensate for a lack of class visits. Therefore, curriculum advisors should visit schools to assess whether or not principals are indeed managing teaching and learning.

5.3 IMPLICATIONS

The findings from the study have certain implications for the understanding of issues associated with instructional capacity in mathematics in secondary schools. One important implication is the idea that a school's instructional capacity in mathematics is defined more accurately in terms of both the individual teacher and the organisational components. In the cases of schools 6 to 10, for example, there were schools that: had over-crowded mathematics classrooms; deployed non-qualified mathematics teachers to teach in Grades 8 and 9; focused too much on Grade 12 at the expense of other grades; used the emerging memorandum-chalk-and-talk method; and lacked support and guidance for students in terms of the choice between Mathematics or Mathematical Literacy, the organisational culture (or instructional culture) of a school in mathematics will not be rebuilt easily. In such a school, constructing a school's

capacity has to do with more than simply having a complete staff complement. It includes intangibles, such as: student distribution in class; ensuring that students who enter the grade without the necessary proficiency receive mathematics skills support; considering student work and teacher recommendations when selecting students for the mathematics stream; and staff development and deployment practices at the school.

A second implication is that the resources upon which instructional capacity in mathematics are built, are variable and multi-faceted. While monetary and other physical resources often come to mind first when considering the development of instructional capacity in mathematics, the case of schools 6 to10 illustrates the importance of the "student as a resource" for instructional capacity in mathematics. Students bring background knowledge, skills, motivation, attitudes and goals to the learning processes of a school (Earnest & Balti, 2008). In the South African context, the student's role in shaping the character and quality of instructional capacity in mathematics in a school is very clear. This is because South African students: have the freedom to choose mathematics; are not required to pay school fees; and also determine the post-provisioning and resource allocation by government to schools. Without a mathematics classroom with 35 or fewer students, a strong school promotional policy and everything else that students bring with them to school, it is very difficult to imagine the existence of an instructional capacity in mathematics in a school that enhances high level student performance in mathematics. In this regard, Even and Kvatinsky (2009) assert that students who arrive at a secondary school with a history of constant failure in mathematics usually withdraw from further efforts to learn and succeed in mathematics'; but suitable learning environments that emphasise a student's strengths allow many of them to create sound mathematical products. Therefore, it is important that careful and systematic analysis and description of school resources includes intangible resources.

A final implication of this analysis is that individual schools should identify, define and accordingly deploy their share of resources to shape and retain instructional capacity in mathematics. As illustrated by School 6, it is not only the presence or absence of a particular set of resources that is important in defining a school's instructional capacity in mathematics, but also how these resources interact with other resources and the practices (or culture) of the school.

The final chapter, Chapter 6, provides a summary of the study, the conclusions derived from the study, and the recommendations on how to construct, organise and replenish instructional capacity in TLM in secondary schools.

CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The previous chapter discussed the research findings and their implications. In this final chapter, a summary of the study, the conclusions and recommendations will be presented.

6.2 SUMMARY OF THE STUDY

Over the years in South Africa, success in Grade 12 was largely dependent on the end-of-year examination performance. In 2006, a new curriculum (NCS Grades R-12), based on the philosophy of outcomes-based education (OBE) was introduced in Grade 10 with a view to having Grade 12 students write an end-of-year examination based on this curriculum in 2008. However, the combination of new instructional methods (brought about by the new curricula) and accountability pressures put many (mathematics) teachers in a quandary when implementing the new methods in terms of striking a good balance between teaching mathematics facts and calculation procedures and developing a good conceptual understanding of mathematics. Given this problem, the state of affairs concerning the pass rates in the Mathematics matriculation examinations of 2008 and 2009 in the MWC reveals that: of the 306 candidates who wrote the examination in 2008, only 41.5% passed; and of the 328 candidates who wrote the examination in 2009, only 32.9% passed. This observation aroused interest and led to the exploration of how the pass rates in the Mathematics matriculation examinations could be improved through school-wide organisational resources and arrangements that are set up to promote quality of TLM at all times, with the aim to break with the past in the approach taken to integrate a commitment to quality instruction with the demands of high-stakes testing.

The leading exploration question was: How then is instructional capacity in TLM constructed, organised and replenished in public secondary schools in the MWC? This gave rise to a number of questions that summarise the main research question addressed by the present research, i.e.: (a) What is the level of instructional capacity of mathematics teachers? (b) How do mathematics teachers identify, mobilise and activate resources for mathematics instruction? (c) What other challenges do mathematics teachers experience in the process of developing instructional capacity? (d) What contribution, if any, do students, principals of

schools and mathematics curriculum advisors make to the development of instructional capacity?

The rationale of the study is rooted in the hope that it will serve to inform decision makers within the MWC, the district and the DoE at large on: how the new curriculum is being translated into action; and how teachers' knowledge, perceptions and experiences impact on the (de)construction of capacity for quality instruction in TLM. Besides this, mathematics teachers will gain an understanding of the instructional behaviours and practices of teachers that result in higher student learning gains.

The theoretical framework that underpinned the study is the five key dimensions of instructional capacity that are likely to shape teaching and learning in a school, i.e.: individual teachers; instructional culture of the school; instructional programmes; the nature of the instructional leadership; and the quality and quantity of technical or material resources for teaching and learning. The inter-connectedness of these five dimensions of instructional capacity formed the basis of the presupposition that TLM could be improved through school-wide organisational resources and arrangements. Therefore, among others, the ability to offer quality instruction in mathematics is determined, not only by the presence of particular resources, but also by the various school participants (parents, principals, subject advisors, teachers and students), the construction and organisation of such resources and their maintenance or replenishment. The study therefore sought to establish instructional capacity as a phenomenon that allows schools to offer quality instruction in TLM. One important way to strengthen the validity of such research findings is through the use of a variety of data sources (Finlay, 2006c). Qualitative data were collected using three different methods, namely, document analysis, observations and interviews.

Five low-performing and five high-performing schools were selected, based on the pass rates in mathematics in high stakes examinations in 2008-2009. I observed lessons and interviewed: ten Grade 12 mathematics teachers, ten principals, five curriculum advisors and a sample of forty Grade 12 mathematics students.

Data collection was preceded by a pilot study entailing the use of the observation inventory and open-ended questions in the semi-structured interview schedules at two schools in the MWC of the Vhembe District. The participants were eight Grade 12 mathematics students, two Grade 12 mathematics teachers, two principals and a mathematics advisor. The use of

schools in MWC both in the pilot study and main study, respectively, did not threaten the credibility of the study, because the study is descriptive and does not require any interaction of variables. The outcome of the pilot study was divided into two categories, namely *practical considerations* and *assessment of instruments*. Practical considerations that needed attention included: the time limit per interview session; and keeping the interview session active. The time limit per interview session was set at 10-20 minutes initially. It emerged that this time limit was much too short and the time allowed was changed to 20-30 minutes in the middle of the pilot study; thereafter the interview process was satisfactory in terms of courtesy, clarity and pace and relevance of the content.

In terms of the assessment of instruments, piloting of the research instruments resulted in the identification of issues that hindered the successful implementation of the reform-oriented practices in TLM, as emerged from the teacher, students, principal interviews and lesson observations. The negative issues raised related to over-crowded classrooms, poor student attitude to mathematics, the progression criteria for grades, a lack of parental involvement in mathematics learning, a weak foundation in earlier grades, a shortage of qualified mathematics teachers, workshops that are out of touch with classroom situations and a lack of curriculum management. On the basis of these issues, the most important finding was that interview questions had to be adapted to create an opportunity to tap data, based on the issues identified during piloting, before being implemented in the main study. Adaptation of the main research instruments formed the basis for further consultation with experts in mathematics education, prior to implementation in the main study. Feedback from mathematics education experts on the operational feasibility, clarity, length, content and relevance of the main instruments was positive.

Since the study sought to produce descriptions of the practices that exemplified the unique organisation of resources and materials at each school, those official documents that have a direct bearing on TLM were chosen. This was done to establish the principal's means of checking: whether or not work is done; coherence of instructional programmes in mathematics; availability of materials or physical resources for TLM; and compliance of time-table with the NCS policy in terms of the number of periods for mathematics per week and per grade level.

Investigation of capacity within mathematics classrooms was also important. Classroom observation focused on interaction between the teacher, students and materials. This was

done to collect data on: resources contributed by the teachers (such as teachers' knowledge and skills and their attitude to content, students and innovation in general); students' engagement with teaching and learning and the use of physical materials (such as textbooks, material technologies including print, video and computer-based multimedia, manipulatives and facilities available for learning); and, the nature of intellectual tasks and problems and the discourses through which content is presented in a particular mathematics classroom. Qualitative data were collected using three different methods, namely, audio-visual recordings, observation and interviews. A total of 10 lessons of approximately 35 minutes each were recorded. After each recording, tapes were viewed thoroughly; thereafter information-rich episodes on teacher intervention and student collaboration were identified, time-annotated and transcribed. Then, the tape was replayed to the teacher, who was asked to interpret and comment on the occurrences in these episodes. Some of the students and the teacher (for each observed lesson) were interviewed to obtain feedback about learning mathematics through social interaction. These interviews were audio-taped and transcribed to supplement the data collected.

Interviews were also held with all ten principals and five mathematics curriculum advisors before classroom observation occurred. They were interviewed in their respective offices. The main question of focus was: *How do they support mathematics teachers in adapting to the demands of the NCS?* The guiding open-ended questions for principal and curriculum advisor interviews, therefore, included questions about how they built capacity for TLM in the areas of: the teacher's knowledge, skills and attitudes; the shortage of qualified mathematics teachers; students' weak foundation in mathematics in previous grades or schools; the lack of parental involvement in mathematics learning; the criteria for progression of students through the grades; alleged poor student attitude to mathematics; over-crowded classrooms; and problems related to the language of teaching and learning.

Given the diversity of the social world, the consistency of the means of data collection is largely irrelevant in the case of qualitative research. Moreover, qualitative research – by definition – involves subjective interpretation (often delivered by both participants and researchers) (Finlay, 2006c). If one accepts that interpretation cannot be excluded from the research process, it follows that any one analysis can only be presented as a tentative statement opening up a limitless field of possible interpretations. In this regard, rather than demonstrate reliability of research instruments, the concern was about showing that findings

can be transferred and *may* have meaning or relevance if applied to other individuals, contexts and situations.

Mindful of differing assumptions and commitments arising from chosen methodologies, credibility was thus addressed by providing the conceptual framework that formed the basis for this investigation, i.e.: the use of triangulation, tape recordings, describing the socio-economic status of the communities in which the schools were situated; the school's broader context; the condition of the buildings and the type of social relationships that prevailed. Apart from this, focus was reflexively on how the social relationship that prevailed might have influenced the research process and its outcomes. In this particular study it implied that I was a teacher in the same district as the selected schools and therefore I already had social status in the group, which posed a threat to the credibility of the study. Therefore ensuring that preconceived ideas and knowledge did not result in bias when interpreting the research data was important. This was achieved by corroborating findings by means of tape recorders, literal transcription of participants' responses and quotations from documents.

In the study, the analysis of data involved the teaching and learning practices of the teacher and the students in the classroom. The statements from respondents were matched with the information on biographical questionnaires, evidence from documents and observational records. Finally, the statements were checked for consistency with the theoretical framework established earlier. All data from interviews were analysed using the procedure for qualitative data analysis, which involved developing units and categories, searching for patterns and then interpreting the results.

The study on how the NCS constructed, organised and replenished instructional capacity in TLM in a secondary school, focused on tapping some of the contextual challenges and successes in ten schools in the Vhembe District of Limpopo Province. The research revealed that the capacity to encourage the new curriculum reform practices in TLM within different schools was often inadequate, and largely failed to compensate for organisational effects and arrangements that shape the capacity to create quality instruction in mathematics. However, high-performing schools were ahead of low-performing schools in terms of encouraging reform-oriented teaching and learning in mathematics. However, it is important to note that CAPS came about as a result of reorganisation of curriculum and assessment, that is, we note that the change from NCS to CAPS is characterised by the subtraction and addition of specific unit content and a reduction or addition in the number of assessment tasks within a

school calendar year. For example, the introduction of Annual National Assessment (ANA) at the end of foundation (Grades R-3), intermediate (Grades 4-6) and senior (Grades 7-9) phases and that probability in the FET (Grades 10-12) phase will no longer be part of an optional paper (Paper 3). Hence the findings of this study remain valid, even for future curricula, because the focus was on instructional capacity in TLM.

6.3 DISCUSSION OF FINDINGS

The study was intended to tap some of the contextual challenges and successes in ten schools in MWC regarding how they constructed, organised and replenished instructional capacity in TLM. The findings of this study showed that it is not only the presence or absence of a particular set of resources that is important in defining a school's instructional capacity in mathematics, but also how these resources interact with other resources and the practices (or culture) of the school. Most teachers who were observed did not integrate knowledge of mathematical content and knowledge of general pedagogical techniques to result in mathematical knowledge in teaching. This *mathematics knowledge in teaching* is not necessarily separate knowledge, but it is demonstrated in the class by how well a teacher uses mathematical and pedagogical knowledge to help students learn mathematics (Sorto & Sapire, 2011). In essence, most teachers struggled somewhat with the issue of how best to present students with a well-sequenced series of activities that help students acquire the underlying mathematical concept (for example, EXTRACT 2, Section 4.3.1.2). In fact, the modes of pedagogy they employed in the classroom relied heavily on the transmission of knowledge model, instead of employing facilitative learning. Facilitative learning occurs when the teacher acts as a facilitator. That is to say, in facilitative learning, the teacher creates the conditions for learning without seeking to control the outcome (see Section 2.3.1.3). This notion underscores the importance of collaboration between students and the facilitator as they engage in a cooperative enterprise that implies a continual process of activity, reflection, collaboration, analysis, the enhancement of critical reflection and self-directedness (Mitchell, 2010:4).

Furthermore, mathematics education is frequently categorised to distinguish between teacher-centered and student-centered instruction, where the traditional instructional mode is characterised by teacher-centered instruction, as the teacher mainly explains procedures and gives directions (Even & Kvatinsky, 2009). On the other hand, student-centered instruction (facilitative learning, advocated by OBE) is characterised by interaction and communication

in learning. This occurs when the teacher emphasises the mathematics content and gives students opportunities to present their perspective on the content. This corresponds to a great extent to research about important pedagogical principles in instructional practice (Roberts & Tayeh, 2007), but was absent in most of the lessons observed at low-performing schools. However, **EXTRACT 1** (see Section 4.3.1.2) indicates student-centered instruction that supports students' mathematical learning. In this extract, interaction and communication among students took place and the teacher took responsibility for knowledge construction by emphasising the mathematics content and also by giving the students an opportunity to offer their perspective on the content.

Even and Kvatinsky (2009) reiterate that, in the student-centered mode of teaching, the teacher is vital for initialising students' processes of knowledge construction. The instructional practices are supposed to be characterised by limited teacher intervention and by interaction and communication between students. From the interviews with teachers, it became clear that they were not adequately trained in the NCS (see Appendix E). The following teacher's disapproval regarding professional development workshops is apparent:

> T4: "… These teacher professional development workshops are disconnected from classroom practices … Seeing someone teaching, as if students are there, provides us with richer knowledge and more informed strategies for improving teaching practices …"

Conclusively, teachers' exposure to the demands of the NCS was limited to general guidelines offered by teacher's manuals (such as work schedules and assessment plans) and a short period of professional development workshops that sought to acquaint teachers with the new content in the curriculum. Therefore, without systematic and sustained support, teachers might resist the proposed reform quietly. This finding suggests that teachers are still in need of continuous and sustained support if they are to properly implement the reforms in their instruction and realise their full potential in supporting student learning. This can be achieved through organising workshops that teachers run and where they demonstrate their own (successful) lessons to their colleagues.

From the data it is evident that a school's instructional capacity in mathematics is defined more accurately in terms of both the individual teacher and the organisational components. In the cases of schools 6 to 10, for example, there were schools that: had over-crowded mathematics classrooms; deployed non-qualified mathematics teachers to teach in Grades 8 and 9; focused too much on Grade 12 at the expense of other grades; used the emerging

memorandum-chalk-and-talk method; and lacked support and guidance for students on the choice between Mathematics or Mathematical Literacy. Some principals focus only on Grade 12 and neglected what transpires in Grades 1 to 11 (see Section 5.2.3). These principals have since expressed their concern regarding poor student performance in mathematics, e.g.:

> P10: "… If we want to improve our mathematics pass rate we should do away with the practice of having unqualified mathematics teachers teaching mathematics. At this school, every year the percentage pass rate in mathematics is deplorable … I have one foreign mathematics teacher teaching Grades 11 and 12, but results are not coming because teachers who are teaching Grade 8, 9 and 10 are not qualified to teach mathematics."

Unlike most FET subjects with a two or three year curriculum, mathematics has a 12 year curriculum. Mathematics is significantly different from other subjects in that every topic requires prior knowledge. The entire syllabus is integrated and dependent on some sound algebraic skills and a feel for numbers. Therefore we need good TLM in all grades to ensure students perform well in Grade 12. Hence there is a need in the lower grades for qualified mathematics teachers in order to attain high achievement levels in mathematics in Grade 12. Situations in which principals replace mathematics teachers with unqualified ones, but do nothing to address the negative effects caused by such practices, are deplorable. One principal complained**:**

> P8: "… Teachers who are not knowledgeable in mathematics weaken the foundation in earlier grades. I have learnt to live with it, but it's killing our results at Grade 12."

Faced with the shortage of qualified teachers and the sad reality of a weakening of the foundation of students in earlier grades, principals should find ways to compensate for the lack of foundation provided in earlier grades. For example, in parallel programmes, the affected grades could be taught the basics in the afternoon by a qualified mathematics teacher (paid from school coffers or otherwise). That being the case, principals should also ensure that the progression criteria through the grades is not fraudulent and does not cover up for incompetent teachers, as expressed below**:**

> P6: "… I have adapted the policy on progression criteria through grades … In fact I have adapted this policy to suit the problems and circumstances at the school. I avoid failing students in large numbers to give space to the other students, and prevent drop-out or exodus to other neighbouring schools, where the record for repeaters is lower, also through manipulation …"

On the basis of responses from students, teachers and principals, the following recommendations with regard to student progression through grades will facilitate a desirable learning environment in mathematics.

First, principals should establish a promotion committee comprising subject HoDs. These HoDs carry the mandate of their respective subject teachers. Corroborating this view, a principal at a high-performing school explained:

> P2: "… I have a promotion committee made up of subjects HoDs. The HoDs carry the mandate of the respective subject teachers … Here the aspect of whether promoting a specific student would benefit the student is discussed and often those students that are weak in mathematics are assigned to do Mathematical Literacy, in the case that they have passed all other subjects. Normally parents agree with the committee's justification for not promoting a student."

This promotional practice is confirmed by a student from that same school (School 2), when clarifying how students elect to do mathematics:

> S6: "… Our mathematics teachers normally advise us to either do Mathematics or Mathematical Literacy, depending on our performance in Mathematics in Grade 9. So I can say teachers assign us to do Mathematics, if one demonstrates potential in the subject …"

Second, a collaborative approach to discourage the use of memoranda as a means to an end by both teachers and students would have a positive effect on TLM. It was deplorable to hear some students narrate how they used mathematics memoranda in preparation for examinations, e.g.:

> S23: "… The memorandum is not doing any good to us as students, because we tend to memorise the workings of questions in the memorandum, but it's not all … During examination time, it becomes difficult to attempt the questions …"
> S32: "… Our teacher always makes sure he writes the memoranda of all written tests and examinations on the board as corrections, so that we can copy for our own revision … So, you know what, we normally memorise the memoranda when preparing for the examinations …"

These assertions by students suggest that their experiences in the classroom are not conducive to mathematics learning, bearing in mind that, according to Even and Kvatinsky (2009), teachers should provide sufficient support for students' mathematical progress, but also hand over responsibility to the students for managing their own thought processes. When the teacher provides students with memoranda for correction, it hinders students' mathematical progress. This view is corroborated by the following view of a teacher:

T9: "… We have a serious challenge at this school … our students have a tendency of memorising the memoranda of previously written mathematics matriculation examination papers in preparation for their final mathematics matriculation examination … this has contributed negatively to their performance in mathematics …"

Lastly, teachers' concerns (stemming from time constraints, the pressure to cover the curriculum and large classes) negatively affect TLM. This may account for the persistent use of teacher-dominated discourse strategies in the observed lessons. As one teacher explained:

T9: "… We work under extreme pressure … heavy workload coupled with large class sizes and the demands of the revised NCS. However, regardless of these challenges, one has to focus much on the end of term CASS marks for accountability purposes. Therefore, covering the content must take precedence over anything else …"

There is, therefore a need for principals to refrain from enrolling students who cannot be accommodated in existing classrooms; as one teacher stated:

T8: "… Principals should avoid enrolling so many students where there are few classrooms, resulting in classes being over-crowded, for their own selfish ends … a notch in their salaries …"

Teachers also complained of an over-emphasis on Grade 12 classes at the expense of the lower grades. One teacher voiced the following concern:

T9: "… Work schedules for Grade 10 and 11 can never be finished within the stipulated time-frame without extra teaching during weekends or holidays. On the other hand, the SMT are reluctant to pay for such extra teaching, except for the Grade 12. There is too much or unparalleled focus on Grade 12, as compared to Grade 8, 9, 10 and 11, because no one knows or bothers to know what is taking place in those grades. Therefore the obvious thing is students move to Grade 12 with uncompleted content of previous grades. As a result, the pace at which we teach these students at Grade 12, in order to bridge the gap created, does not take on board the slow students - hence low achievement levels of students in mathematics matriculation examination …"

So organising of extra lessons should also be extended to other grades (other than Grade 12 alone), to ensure that students' opportunities to learn are coherent within and across grade levels.

6.4 CONCLUSION

In conclusion, firstly, the data of this study presented two major findings. Teachers generally demonstrate knowledge of mathematical content at the grade level they are teaching and also

demonstrate knowledge of general pedagogical techniques. However, most teachers do not integrate these two domains of knowledge effectively. More specifically, most teachers do not present students with a well-sequenced series of activities that help students acquire the underlying mathematical concept. This was despite the numerous in-service preparation sessions teachers were exposed to (prior to and during implementation) and the various materials hand-outs, even though no formal follow-up was done to evaluate the impact of such in-service programmes. Based on this, the conclusion was that the success of in-service programmes should not be determined by merely making sure all teachers attend the teacher development programmes. Instead, the way that the ideas, knowledge and skills learnt are implemented in a classroom setting is a crucial measure of the success of such a programme.

Furthermore, T6's task-oriented concern was that of completing the content, hence he could not engage students in collaborative learning (see EXTRACT 2, Section 4.3.1.2). Therefore, based on what happened in T6's lesson, the conclusion is that for any in-service programme to be successful, especially one that introduces teachers to a different instructional approach from the traditional one, it has to impact on teachers' concerns (be they self-oriented, task-oriented or impact-oriented).

Secondly, in the case of schools 6 to 10, for example, there were schools: that had over-crowded mathematics classrooms; deployed non-qualified mathematics teachers to teach Grades 8 and 9; focused too much on Grade 12 at the expense of other grades; used the emerging memorandum-chalk-and-talk method; and lacked support and guidance for students on the choice between Mathematics or Mathematical Literacy. This means that the idea that schools should coordinate instruction internally seems unusual in practice in schools. Therefore the conclusion, *inter alia*, is that it is very difficult to imagine the existence of an instructional capacity in mathematics in a school that enhances high level student performance in mathematics without: qualified teachers, a mathematics classroom with 35 or fewer students, a strong school promotional policy, observing teachers teaching and everything else that students bring with them to school. Therefore, it is important that a careful and systematic analysis and description of school resources includes intangible resources. Mindful of that, it is not only the presence or absence of a particular set of resources that is important in defining a school's instructional capacity in mathematics, but also how these resources interact with other resources and the practices (or culture) of the school.

6.5 RECOMMENDATIONS

6.5.1 Introduction

In light of the conclusions provided above, the following recommendations are provided regarding how schools, as educational institutions, could construct, organise and replenish their instructional capacity in TLM.

6.5.2 Recommendations

6.5.2.1 Employ facilitative learning

Facilitative learning is based on the premise that learning will occur by the teacher acting as a facilitator, that is, by establishing an atmosphere in which students feel comfortable to consider new ideas. Good teaching is generally seen as the ability to set a certain emotional climate, to use students' experiences as educational resources, to provide plenty of evaluative information to students, and to encourage collaboration and participation (Section 2.3.1.3). The involvement of all students (as demanded by OBE) entails calling on students to share and discuss their thinking and their viewpoints. Students should explain their strategies to resolve an issue and raise questions or problems in pairs or small groups through cooperative learning. One group member should then share the group's thoughts with the whole class (see Section 2.3.1.3). Such is the beauty of facilitative learning (see EXTRACT 1, Section 4.3.1.2)

6.5.2.2 Promote the instructional climate

As indicated in Section 5.2.4, there is a need for principals to manage teaching and learning by setting a framework for this, developing relevant policies and ensuring that curriculum delivery is being implemented successfully. However, research shows that most principals have a weak grasp of teaching and learning. Their instructional leadership is often confined to checking that work has been completed, rather than making informed judgements about the quality of teaching and learning (Bush & Glover, 2009).

In the interviews with principals (see Appendix E), it was discovered that the substitution of a professional approach to teaching for the unionist approach contributed to the demise of a culture of teaching and learning in schools. Principals P4 and P6 blamed teacher unions for their failure to observe teaching. With this in mind, it is suggested that the principal emphasises the need for an internally developed clinical supervision programme through collaborative decision making in order to promote a sense of ownership by all mathematics

teachers. Such a supervision programme will enhance commitment and ensure mathematics teachers' efforts are unified towards improving TLM.

Apart from that, the essential tools for managing teaching and learning are modelling, monitoring and evaluation (Chisholm *et al.*, 2005). HoDs and school principals should provide good models in terms of lesson preparation, subject knowledge, pedagogic approaches, assessment and student welfare (Chisholm *et al.*, 2005). They should monitor teacher practice in a systematic way and provide constructive feedback.

Recent research by Robinson (2007) shows that successful school principals are able to raise standards by motivating and inspiring teachers. Principals raise standards by developing and implementing effective evaluation and by monitoring classroom practice (including direct observation) and through direct engagement with parents and the local community. By so doing, they limit the impact of unpromising contexts on student achievement.

6.5.2.3 *Focus teacher professional development on mathematical knowledge in teaching*

Easton (2009) says emerging questions or concerns that teachers have as they are introduced to and take on new programs, practices or processes range from questions that are more self-oriented and task-oriented, to questions that are more impact-oriented (see Section 2.2.2.1 (b)). Teacher concerns can guide the selection of strategies for professional development and provide insight into the content of strategies in order to adequately address teachers' needs and concerns as they go through the change process (Easton, 2009).

What type of workshops do we then have to create to bring about change in TLM? Of course, change in materials (content) has the potential to change the interactions of teacher, students and materials - and hence to affect instructional capacity. Hence, if instructional capacity is a property of interaction among teacher, students and materials, then interventions are likely to be more effective if they target more interactions among those three elements of instruction, rather than focusing on one element in isolation. Therefore, interventions that focus, not only on aspects of particular elements, but also on their relationships, are more likely to improve capacity (Loucks-Horsley *et al.*, 2010: 163). From the interviews with teachers (see Appendix E), it emerged that there is a need for the DoE to change its models of professional development in order to focus on mathematical knowledge in teaching. One teacher queried:

T10: "… I think the curriculum advisors' conception of professional development sometimes seems confined to content knowledge only … the activities at the workshops seem intended to enhance teachers' knowledge of subject area … What about pedagogical content (subject-specific pedagogy)?"

Re-conceptualising professional development to align with the needs of teachers allows us to shift our efforts from a 'one-shot, sit-and-get' model to one in which teacher learning becomes part of the daily routine (Hunzicker, 2010:177). It is therefore clear that teachers support workshops that transform their classroom practice, perhaps with the opportunity for follow-up to help them adapt the knowledge and skills to their own specific situations. Furthermore, after they practice new methods in their classrooms, they need opportunities to meet with other teachers to discuss what is working and how to make refinements (Loucks-Horsley *et al*., 2010: 163). Therefore, observing one of their own teaching may inspire teachers to succeed themselves, even though the content and methods may initially seem foreign to them.

6.5.2.4 Deploy qualified teachers in all grades

It is the "intellectual ability, knowledge and skills" of the individuals involved in the teaching and learning tasks that impact on job performance and effectiveness in the classroom (Heck, 2007). Focusing on Grade 12 at the expense of other grades impacts negatively on the achievement levels of students, because mathematics is a 12-year syllabus. Mathematics is significantly different from other subjects, since each topic requires prior knowledge and the entire syllabus is integrated and dependent on some sound algebraic skills and a feel for numbers. Therefore, we cannot deploy qualified teachers only at Grade 12 and neglect the other grades.

The deployment of qualified teachers only at Grade 12 level has adversely affected student performance. As one principal complained:

P10: "… If we want to improve our mathematics pass rate, we should do away with the practice of having unqualified mathematics teachers teaching mathematics. At this school, every year the percentage pass rate in mathematics is deplorable … I have one foreign mathematics teacher teaching Grades 11 and 12, but results are not coming, because teachers who are teaching Grade 8, 9 and 10 are not qualified to teach mathematics."

Therefore it is recommended that the affected schools develop context-based strategies to enhance student performance, such as: professional development for non-qualified teachers;

the modelling of good practices by effective teachers or HoDs; and monitoring of performance of less effective teachers (Bush & Glover, 2009). Again, HoDs should act as mentors by modelling good instructional practices, such as leading by example. HoDs can only do this, however, if they know what is going on in classrooms through direct observation of teaching.

6.5.3 Summary

From the exposition above, it is clear that the key to improving students' performance is largely dependent on principals, HoDs, teachers and students assuming their respective roles in TLM. This implies the need for principals and HoDs to provide teachers with systematic and sustained support, such as professional development workshops. These workshops should be based on an underlying constructivist view of learning and they should provide vision, leadership and guidance on curricular content and instruction. In essence, the workshops should aim to integrate knowledge of mathematics content and knowledge of general pedagogical techniques to result in mathematics knowledge in teaching. This *mathematics knowledge in teaching* is not necessarily separate knowledge, but it is demonstrated in the class by how well a teacher uses mathematical and pedagogical knowledge to help students learn mathematics (Sorto & Sapire, 2011).

Principals should establish evaluation or accountability mechanisms through participatory decision making and provide resources directly, while also facilitating access to outside sources of support. The involvement of parents, students, teachers, principals and curriculum advisors in establishing evaluation mechanisms will promote a sense of ownership among all parties involved. This will boost commitment and ensure that all efforts are unified towards improving the quality of TLM.

6.6 LIMITATIONS OF THE STUDY

As a research thesis based on a qualitative method, this study of how schools (as education institutions) construct, organise and replenish a school's capacity in TLM for the improvement of student learning (with particular reference to the Vhembe District of Limpopo Province in South Africa), demonstrated both the strengths and limitations intrinsic to such an investigation. Although the small sample is a limitation, the research aims were not to provide generalisations, but rather to explore the problem. The strength lies in the fact that data analysis provided a rich source of information. Purposeful sampling also allowed for

a selection of respondents viewed as founts of useful information. Lastly, the exclusion of SGB members may have limited the study.

6.7 SUGGESTIONS FOR FUTURE RESEARCH

This study creates opportunities for further research in the South African context. The experience gained during lesson observation raises the following questions:

- Is there a difference in achievement of students in quiet classrooms and those in noisy (student-peer conversation) mathematics classrooms - and if so, why?
- In what way does classroom organisation hamper or enhance communication in the mathematics classroom?

These two research questions might be worth pursuing through qualitative research.

6.8 CLOSING REMARKS

This research was aimed at ascertaining what constitutes instructional capacity in TLM in the era of the NCS implementation. From the literature study, lesson observation data and interviews, key factors that had a negative and a positive impact on students' performance in mathematics were identified. It was concluded that a school's instructional capacity in mathematics is defined more accurately in terms of both the individual teacher as well as the organisational components. It is in light of these factors that some recommendations were provided regarding how teachers, principals and the DoE could collaborate in their endeavours to improve the quality of instruction in mathematics classrooms.

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Appendix A: LETTERS OF PERMISSION

LETTER TO PRINCIPALS OF SCHOOLS:

REF : 83023011

ENQ. : CHIGONGA B.

Cell : 0837749641

email: bchigonga@cooltoad.com

P.O. Box 1991

Malamulele

0982

16th August 2010

ATTENTION: The Principal (for action).

Sir/Madam

RE: PERMISSION TO USE YOUR SCHOOL AS A RESEARCH SITE

I am a PhD degree (Mathematics Education) student with the University of South Africa. In partial fulfilment of the requirements for the degree, I am conducting a study entitled: I**mplementing the National Curriculum Statement: how is instructional capacity in the teaching and learning of mathematics constructed, organised and replenished in secondary schools**?

This study is aimed at finally assisting mathematics teachers to improve the quality of instruction in mathematics in schools. Data will be collected using document analysis, observation and interviews. I intend to interview five Grade 12 mathematics students, a Grade 12 mathematics teacher and your honourable self. I am therefore asking for permission to use your school as a site for this study.

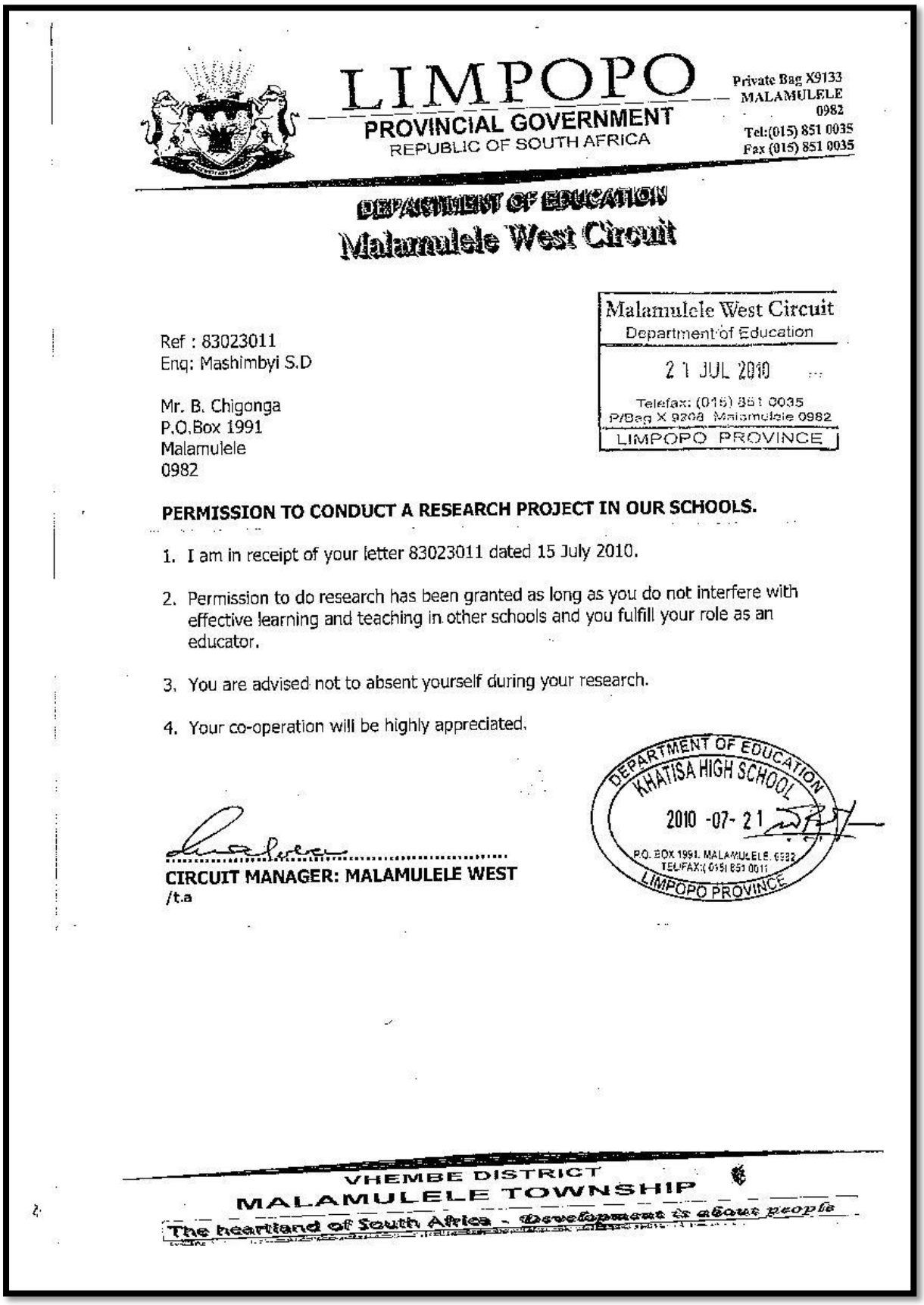
Thanking you in anticipation.

Yours faithfully

.....

CHIGONGA BENARD (Mr)

DISTRICT PERMISSION LETTER:



LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

Private Bag X9133
MALAMULELE
0982
Tel:(015) 851 0035
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DEPARTMENT OF EDUCATION
Malamulele West Circuit

Malamulele West Circuit
Department of Education
21 JUL 2010
Telefax: (015) 851 0035
P/Bag X 9308 Malamulele 0982
LIMPOPO PROVINCE

Ref : 83023011
Enq: Mashimbyi S.D

Mr. B. Chigonga
P.O.Box 1991
Malamulele
0982

PERMISSION TO CONDUCT A RESEARCH PROJECT IN OUR SCHOOLS.

1. I am in receipt of your letter 83023011 dated 15 July 2010.
2. Permission to do research has been granted as long as you do not interfere with effective learning and teaching in other schools and you fulfill your role as an educator.
3. You are advised not to absent yourself during your research.
4. Your co-operation will be highly appreciated.

DEPARTMENT OF EDUCATION
KHATISA HIGH SCHOOL
2010 -07- 21
P.O. BOX 1991, MALAMULELE, 0982
TEL/FAX:(015) 851 0011
LIMPOPO PROVINCE

CIRCUIT MANAGER: MALAMULELE WEST
/t.a

VHEMBE DISTRICT
MALAMULELE TOWNSHIP
The heartland of South Africa - Development is about people

Appendix B: INFORMED CONSENT FORM FOR INTERVIEWEES

Excuse me!

1. I am BENARD CHIGONGA, a PhD student at UNISA doing educational research.
2. I am conducting a survey among Grade 12 mathematics students, mathematics teachers, principals and mathematics curriculum advisors in the selected public secondary schools in Vhembe District.
3. The purpose of the research is to find out what constitutes instructional capacity – the capacity to produce worthwhile learning – in the teaching and learning of mathematics in the area of outcomes based education curriculum implementation. In other words, I want to know what is it that schools are doing to succeed or fail in mathematics.
4. The role the interview plays in the research is to determine specific circumstances and conditions under which principals and mathematics teachers work in order to gather relevant and precise information from which to draw conclusions.
5. The information provided will be used only in combination with that from other selected public secondary schools from the Vhembe District and will be treated confidentially.
6. Anonymity will be ensured by the use of disguised names in the subsequent publication of research findings.
7. The interview will take 20-30 minutes.
8. You may withdraw your participation in this interview at any time, should you so wish.
9. Kindly tick the appropriate boxes provided.

- Are you free to participate in this interview?

Yes		No	

- May I tape your responses?

Yes		No	

NB: If you are interested in receiving a report on the findings of this research, request the results from the researcher at the following email address: bchigonga@cooltoad.com. I will be glad to send you a complementary report once it has been completed.

Appendix C: PRINCIPALS' AND TEACHERS' BIOGRAPHICAL QUESTIONNAIRES

The principals and teachers were asked to fill in biographical questionnaires. I intended to use this information later in the description of the research site, as well as to corroborate data.

BIOGRAPHICAL INFORMATION: TEACHERS

NB:

- Please answer all questions as honestly as possible.
- Your responses will be used for research purposes only.
- Information will be treated as anonymous and confidential.
- Fill in your answer in the space provided.

1. Qualifications: Academic ……..……
   ……..
   ……..
   Professional ……..
   ……...
   .……..
   Other ……...
   .……..

2. What is your present post level? .....
3. Indicate the number of years as a mathematics teacher .....
4. How many years have you been at this school? .....
5. What is the average number of students per class? .....

THANK YOU FOR YOUR COOPERATION

BIOGRAPHICAL INFORMATION: PRINCIPALS

NB:

- Please fill in the spaces provided as honestly as possible.
- Your responses will be used for research purposes only.
- Information will be treated confidentially.

1. Qualifications: Academic ……..
   ……..
   ……..
   Professional ……...
   ……..
   ……..
   Other ……...
   ……...
2. Indicate the number of years as a principal. .....
3. How many years have you been at this school? .....

THANK YOU FOR YOUR COOPERATION

Appendix D: RESEARCH INSTRUMENTS

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1. INTERVIEW QUESTIONS FOR TEACHERS

The theoretical underpinnings of the NCS allow teachers to employ a variety of ways of teaching in order to present opportunities for students to construct their knowledge. Therefore, among other things, the NCS encourages instruction that engages students as active participants in their own learning. The main objective of the study is to establish the challenges, if any, of implementing such reform practices in the mathematics classroom.

- As a mathematics teacher, how are you overcoming the challenges of: students' weak foundation in earlier grades, alleged poor student attitudes to the subject, over-crowded classrooms and the problem of language of teaching and learning?
- When you reflect a little, how would you describe the workshops you have attended in preparation for the teaching and learning of mathematics in the era of NCS implementation?
- In your particular situation, what type of professional development best suits you in the teaching and learning of mathematics in the area of NCS implementation?
- Since the inception of NCS, what support have you received thus far from the curriculum advisor or principal or HoD?
- What support do you anticipate receiving from the mathematics curriculum advisor or principal or HoD to help you improve your teaching skills?
- What are the advantages or disadvantages of giving students mathematics memoranda for written and past examination question papers?

2. INTERVIEW QUESTIONS FOR STUDENTS

- How would you describe your attitude and that of your classmates towards learning mathematics?
- Do you decide or are you assigned to do mathematics and what is your comment on the practice?
- In what way does the mathematics teacher help you during your preparation for the end of term common tests?
- How do you use the mathematics memoranda during your preparation for the mathematics examinations?

3. INTERVIEW QUESTIONS FOR PRINCIPALS

How do you build school capacity for the teaching and learning of mathematics in the following areas:

- Teachers' knowledge, skills and attitudes.
- Shortage of qualified mathematics teachers.
- A weak foundation in earlier grades.
- Lack of parental involvement in mathematics learning.
- The criteria for progression through the grades.
- The alleged poor student attitudes to the subject.
- Over-crowded classrooms.
- Language of teaching and learning problems.

4. INTERVIEW QUESTIONS FOR MATHEMATICS ADVISORS

- What are the challenges, if any, of implementing reform practices brought about by the NCS in the teaching and learning of mathematics?
- How do you identify teachers' instructional strengths and weaknesses to inform professional development opportunities for them in the teaching and learning of mathematics?
- What means are in place for helping teachers adapt their teaching practices to the increasingly diverse learning styles they find in the mathematics classrooms?
- How do you ascertain that the actual teaching of the scheduled content per week, per term and per year is indeed completed?

5. LESSON OBSERVATION INVENTORY

LESSON OBSERVATION INVENTORY	Yes	No
A: LESSON PRE-REQUISITE		
1. Lesson plan available		
2. Media of instruction		
B: REFORM-ORIENTED PRACTICES		
3. Students seated in organised groups		
4. Exposing students to a real life situation (introduction)		
5. Gaining attention: students given stimulus (motivation)		
6. Lesson objectives are outlined by the teacher		
7. Actualisation of existing relevant knowledge		

8. Displaying content (present stimulus material)		
9. Students have necessary materials		
10. Students encouraged to participate in the activity (providing learning guidance)		
C: LESSON MANAGEMENT		
11. Students allowed adequate time to work through the activity.		
12. Solving problems: debate/discussion of answers – individually, whole class, or in small groups.		
13. Teacher directly involves and elicits responses and ideas from the students (asks students to respond, demonstrating learning).		
14. Answering of the questions from teacher.		
15. Teacher places emphasis on student responses and capitalises on the students' ideas.		
16. Pedagogical content knowledge (the notion of helping students understand the concept and ideas).		
17. Content knowledge.		
18. Teacher intervention to help students arrive at objectives of lesson.		
19. Teacher completes work on lesson plan.		
20. Teacher gives informative feedback on student's performance.		
D: LESSON CONCLUSION		
21. Teacher summarises lesson concepts, rules or definitions of the domain of study.		
22. Written exercises and homework assigned that require more student performance to reinforce learning.		
E: CLASSROOM MANAGEMENT		
23. Who talks to whom during lesson?		
24. Teacher paces lesson, ensuring smooth progression.		
F: OVERALL IMPRESSION		
25. The objectives of the instruction were met.		
26. Instruction is tested with students in the form of formative evaluation.		

Appendix E: TRANSCRIPTS OF INTERVIEWS WITH ALL RESPONDENTS

The following are transcripts of interviews with various respondents:

1. TRANSCRIBED INTERVIEWS WITH THE SCHOOL PRINCIPALS

How do you build school capacity for the teaching and learning of mathematics in the following areas?:

- **Teachers' knowledge, skills and disposition**

P1: "…Well … Sir, thank God I don't have staff at my school that say; 'No do not come to my class'. Everybody at my school accepts it (lesson observation) and what goes on with it, like checking students' written work, the planned weekly work, and the frequency of informal tests. So class visits is one way of discovering teachers' knowledge, skills and disposition, which may inform professional development of that teacher. However, I need to point out that I am not a qualified mathematics teacher myself, but I know of good instruction when I see it or to encourage it when I do not …"

P2: "… I would say HoDs, as subject specialists, should have explicit responsibility for leading their subjects. So I rely at most with the mathematics HoD on the classroom goings on."

P4: "… It's a question of faith … Teachers' unions made our role as instructional leaders a bit complicated … I can't observe lessons … neither my mathematics HoD. So we rely on test scores … which are at most bad."

P5: "… It's not easy to ascertain what transpires inside the classroom because of teacher denial. I simply believe they (teachers) have the knowledge and skill to implement the reform efforts … and associate low test scores to the belief that mathematics is a difficult subject."

P6: "… The noble thing to do is to sometimes establish direct observation of teacher's teaching, but teachers' unions said we are not allowed in classrooms. So as a result, I always make sure that teachers and students are in their classrooms and assume teaching is taking place and that the teacher has the knowledge and knows how to dish his content."

P7: "... There is much to learn about the curriculum reform efforts … er … I don't have a formula but I simply believe the concerned teachers know their work …"

- **The shortage of qualified mathematics teachers**

P1: "… In situations where this does happen, then it's unfortunate because our classroom mathematics teachers should be experts in their field for effective instructional practices in the classroom. Here at my school, I don't have such a scenario …"

P6: "… I have a problem here … Well, due to shortage of mathematics teachers, I turned an English teacher into a mathematics teacher as a last resort, even though we restrict him to teach Grade 8 and 9 only … It's a sad situation, but what else can we do?"

P7: "… No one would advocate for non-qualified mathematics teachers to teach mathematics. However, I cannot leave students without a teacher to attend to them. When teachers leave, mostly through redeployments as a result of dwindling enrolment, or for whatever reason, I play the 'substitution game' … I mean I just assign any teacher with fewer periods to help teach mathematics."

P8: "… Teachers who are not knowledgeable in mathematics weaken the foundation in earlier grades. I have learnt to live with it, but it's killing our results at Grade 12."

P9: "… Seemingly, more can be done to improve mathematics education by improving the effectiveness of mathematics teachers than by any other single factor … Qualified mathematics teachers will continue to influence student achievement … However, it's beyond our control when unqualified mathematics teachers teach mathematics. I have English and Geography teachers teaching mathematics at lower classes, i.e. Grade 8 and 9."

P10: "… If we want to improve our mathematics pass rate, we should do away with the practice of having unqualified mathematics teachers teaching mathematics. At this school, every year the percentage pass rate in mathematics is deplorable … I have one foreign mathematics teacher teaching Grades 11 and 12; but results are not coming because teachers who are teaching Grade 8, 9 and 10 are not qualified to teach mathematics."

- **A weak foundation in earlier grades**

P1: "… I have a parallel program, where the Grades 8 and 9 attend four hours a week (in the afternoon), mainly teaching them the basics in mathematics to seal the gap (if any) created during primary level."

P3: "… We organise extra lessons, specifically for teaching Grade 8 and 9 basics in mathematics and Grade 10 to 12 content coverage - because the content is concentrated so that it's not practical to accomplish it within the stipulated time frame …"

P6: "… I know there is that problem, but there is no money to sponsor any extra teaching …"

- **Lack of parental involvement in mathematics learning**

P1: "… I encourage parents to complement the school's instructional programmes by carrying out some of the classroom curriculum at home, i.e. hiring tutors to help with extra teaching/lessons …"

P2: "… Create a forum (consultation day) for opening a dialogue between parents and teachers; discussing their child's progress or problems they might be experiencing at school; advising parents on how to help their children, and by keeping in touch with the parents through newsletters; encourage parents to support classroom and school

activities, assisting children with schoolwork/homework (as a norm); make sure that their children come to school every day and homework is done; asking them to sign students' exercise books after the child has written a test or a project; to parents, who themselves cannot read and write, convene information meetings about the importance of their participation in their children's education …"

P6: "… It has not been easy to get the parents on board because they have an attitude of saying that teachers are the only responsible people for the education of their children as they are being paid for their services. In such a case it becomes difficult to encourage them to help their children with extra lessons …"

- **The criteria for progression through the grades**

P1: "… It needs to be understood that retaining a student in a grade is not a guarantee that this student will improve his or her learning. The same applies to the act of promoting a student with specific learning problems. To bring about change in a student, learning support is required for these students to improve in areas identified as having problems. For example, a student who was promoted at a border-line case or retained in a grade because of his or her poor mathematics skills will not improve, unless a way is found to help him/her overcome an identified learning problem in mathematics. I believe that the better way to improve repetition is only through the provision of quality education."

P2: "… I have a promotion committee made up of subject HODs. The HoDs carry the mandate of the respective subject teachers ... Here the aspect of whether promoting a specific student would benefit the student is discussed and often those students that are weak in mathematics are assigned to do mathematical literacy, in the case that they have passed all other subjects. Normally parents agree with the committee's justification for not promoting a student."

P3: "… If a student passes all other compulsory subjects at Grade 9, except mathematics, I will be convinced that the student would definitely benefit from progressing to the next band, although it's up to the student to either select Mathematics or Mathematical Literacy once in Grade 10 … but often we advise them to take up Mathematical Literacy …"

P4: "… A student who passes all other compulsory subjects at Grade 9, except Mathematics will be promoted to the FET band; but I assign them to do Mathematical Literacy, even if they are electing to do the science subjects …"

P5: "… We have adapted the student promotion policy to fit the conditions at our school. The end of first term tests gives a measure of the performance of each student. Based on these results, at the beginning of the second term, all students in respective grades with learning problems are identified and extra teaching is organised (four hours every week until end of term) for each respective grade. The practice is repeated after every end of term test …"

P6: "… I have adapted the policy on progression … In fact I have adapted this policy to suit the problems and circumstances at the school. I avoid failing students in large numbers to give space to the other students, and prevent drop-out or exodus to other neighbouring schools, where the record for repeaters is lower, also through

manipulation … You know that in life one needs to succeed and it works as a motivating factor."

P9: "… Slow students who are held back may be more harmed than helped in their development. A student may not master everything that is to be learnt in a certain grade, but is more likely to develop by going on to the next grade and acquiring what is possible there, than being kept back."

P10: "… Students who repeat two or three times are much more likely to drop out than students who never repeat. Er … drop-outs increase with over-aged students and enrolment shrinks … So we stay away from that."

- **The alleged poor student attitudes to the subject**

P1: "… Students need to be responsible for their own education … If students believe that they are capable of successfully mastering mathematics tasks, they are also more willing to take their own responsibility for the learning process. So saying positive things about mathematics; sharing of mathematics classes among male and female teachers; making sure mathematics is taught with a qualified mathematics teacher; during study sessions, students are divided into mixed ability groups, so that stronger students can help the weaker students improve mathematics learning."

- **Over-crowded classrooms**

P1: "… We make sure our enrolment does not surpass our resources. So our classrooms here are not over-crowded, because we make sure each classroom has at least 20 students and at most 35 students."

P2: "… Over the years our enrolment has increased such that I have the least number of 68 students in Grade 12; 80 to 90 in Grade 8 and 9. We have applied for mobile classes."

- **Language of teaching and learning problems**

P1: "… Though it is not an easy task, I encourage students to communicate in English and teachers teaching subjects written in English to always teach in English other than vernacular language(s). This is meant to enhance the acquiring of the language by students … Once the students have a command of English, then it will go a long way in improving their understanding of mathematics …"

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2. TRANSCRIBED INTERVIEWS WITH TEACHERS

- **As a mathematics teacher, how are you overcoming challenges of students' weak foundation in earlier grades, the alleged poor student attitudes to the subject, over-crowded classrooms and language of teaching and learning problems?**

T1: "… Class sizes are too big here … making it difficult to address students' individual needs. However, I try to check on the performance of each student by giving my classes

daily written exercises and I mark the exercise books before the next lesson; and I always carry out weekly tests. On the other hand, I try to motivate them by showing commitment, through not absenting myself from school, not arriving late to lessons and a willingness to provide extra classes to help them 'catch up', depending on the weaknesses detected …"

T3: "… I provide extra classes to help students 'catch up'; and during this time students are divided into mixed ability groups, so that stronger students can help weaker students improve in their areas of weakness …"

T6: "… It's not the practice of this school to arrange for paid-for extra lessons … however, one can volunteer to offer extra lessons to help students catch up. Personally, I stay a bit far, so I sometimes come to offer extra lessons … but not always …"

T9: "… We work under extreme pressure … heavy work-load, coupled with large class-sizes and the demands of the revised NCS. However, regardless of these challenges, one has to focus much on the end of term CASS marks for accountability purposes. Therefore, covering the content must take precedence over anything else …"

- **When you reflect a little, how would you describe the workshops you have attended in preparation for the teaching and learning of mathematics in the area of NCS implementation?**

T2: "… It is unfortunate that teachers are summoned for a workshop only to be given materials or should I call them individual study materials … which are first read to us by the presenters … then why call a workshop instead of just sending the materials to schools and spare teachers wasting valuable teaching time for nothing."

T3: "… Most of these workshops are characterised by material giving and reading of the same materials by the presenters. I have only attended four workshops since the inception of NCS. I no longer attend these workshops, but I always make a follow-up on the workshop materials (or hand-outs)."

T8: "… The workshops are best described as 'materials giving workshops' and these materials are at most not easy to follow alone if you did not do the content during training at college."

- **In your particular situation, what type of professional development best suits you in the teaching and learning of mathematics in the era of NCS implementation?**

T1: "… Mathematics is a practical subject. So listening to a presenter from one of these universities will not improve how we should teach the subject … In my view, we should workshop ourselves … by which I mean, to the topic that are said to be problematic, there are classroom teachers who have the knowledge of these topics and I would like them to teach the topic while other teachers observe and learn and then afterwards open a discussion with the help of the university presenters … that way teachers will learn far much better."

T2: "… Let the nature of the workshops be such that teachers showcase how they are teaching in classroom, i.e.: the organisers of the workshops should recruit experienced and exemplary practicing secondary school teachers to serve as presenters at these workshops; and allow thereafter a discussion of the presentation under the guidance of the experts from the universities … The workshops would be relevant and meaningful to teachers and possibly improve their teaching practices and mathematics content knowledge."

T4: "... These teacher professional development workshops are disconnected from classroom practices … Seeing someone teaching, as if students are there, provides us with richer knowledge and more informed strategies for improving teaching practices …"

T7: "... All other things being equal, if these workshops were effective we could have witnessed a marked increase in student achievement in mathematics … So if the workshops cannot support our ongoing growth and development, then it relinquishes significant opportunities to influence teacher practice and student achievement. So they (the Department of Education) should change their workshop models and give teachers a chance to workshop themselves under their watchful eye …"

- **Since the inception of NCS, what support have you received thus far from the curriculum advisor, principal or HoD?**

T2: "… I received support in the form of resource materials (like any other school), such as work schedules, annual assessment programmes, and assessment tasks; but no guidance on how to teach the mathematics content. However, it would be an advantage if formal follow-up is done to observe the implementation of these resource materials and help teachers adapt the implementation to their own situations …"

T6: "… My HoD is the deputy head (a geography teacher). So you can imagine the type of support I receive … In fact he is just a 'tick moderator', i.e. he normally moderates my scripts by mere ticking where I would have ticked and ascertains whether the ticks tally with the total marks awarded … On the other hand, I have not met the curriculum advisor for mathematics, but I believe one is there at the circuit because I always see my CASS mark schedules - signed an indication that there is one …"

T9: "… We are let down by our promotional policies here … there is no clear-cut way of assessing whether teachers are indeed teaching when they are in class, besides depending on the test scores (which are often bad) of the controlled common assessment tasks from the district offices. The blame game then starts: the principal often says the teachers are not teaching and the teachers say the controlled common tests are above the level of the students or the students are not preparing for the tests … as a result students are pushed to the next grade without meeting the laid down criteria. So there is no tangible support from principal or HoD …"

- **What support do you anticipate from the mathematics curriculum advisor, principal or HoD to help you improve teaching?**

T7: "... Let me just put it in a question: What are the instructional characteristics and behaviours of those teachers who produce high gains in student learning? So curriculum advisors should recruit these teachers so that they workshop us by modelling their instructional characteristics and behaviours in a classroom situation. That way we can begin to better understand the link between classroom processes and desirable student outcomes …"

T8: "… Principals should avoid enrolling so many students where there are few classrooms, resulting in classes being over-crowded for their own selfish ends … a notch in their salaries."

T9: "… Work schedules for Grade 10 and 11 can never be finished within the stipulated time-frame without extra teaching during weekends or holidays. On the other hand, the SMT are reluctant to pay for such extra teaching, except for the Grade 12. There is too much or unparalleled focus on Grade 12, as compared to Grade 8, 9, 10 and 11, because no-one knows or bothers to know what is taking place in those grades. Therefore the obvious thing is students move to Grade 12 with uncompleted content of previous grades. As a result, the pace at which we teach these students at Grade 12 in order to bridge the gap created, does not take on board the slow students - hence low achievement levels of students in mathematics matriculation examination …"

T10: "… I think the curriculum advisors' conception of professional development sometimes seems confined to content knowledge only … the activities at the workshops seem intended to enhance teachers' knowledge of subject area … what about pedagogical content (subject-specific pedagogy)?"

- **What are the advantages or disadvantages of giving students mathematics memoranda for written and past examination question papers?**

T2: "… The advantage of the memoranda would be the use by students to refer to it after they have worked out the questions from the past examination papers … However, having the memoranda would cease to be an advantage if students simply study or memorise how a certain question was worked out. In the same vein, as a teacher one cannot teach copying the workings from a memorandum … Both teachers and students need to develop a skill of solving problems, not a skill of following what someone has already done to solve the problem …"

T7: "… At our school we do not give students the memoranda as they are, but we give the answers (not workings) to questions so that they discover the methods to get to the answer … like the mathematics textbooks, answers are given to chapter exercises, but no working is shown."

T9: "… We have a serious challenge at this school … our students have a tendency of memorising the memoranda of previously written mathematics matriculation examination papers in preparation for their final mathematics matriculation examination … this has contributed negatively to their performance in mathematics …"

3. TRANSCRIBED INTERVIEWS WITH STUDENTS

- **How would you describe your attitude and that of your classmates towards learning mathematics?**

S29-32: "… Sir, the reason why we have Mathematical Literacy is because mathematics is difficult. Believe it or not, Sir, why don't we have Geography Literacy? Whether one is gifted or not, mathematics is just a thinking subject …"

S37-40: "… The problem with us students is that most of us do not like mathematics because we were told mathematics is difficult right from the primary school …"

- **Do you decide or are you assigned to do mathematics and what is your comment on the practice?**

S1-4: "… We choose to do mathematics not because we love mathematics, but because mathematics is such an important subject that one cannot afford to do away with … Our parents also tell us to do mathematics, regardless of whether one is good or not … So at times we do mathematics to please our parents …"

S5-8: "… Our mathematics teachers normally advise us to either do Mathematics or Mathematical Literacy, depending on our performance in mathematics in Grade 9. So I can say they assign us to do mathematics if one demonstrates potential in the subject …"

S9-12: "… In primary I was told that mathematics is difficult and is done by those who want to be engineers or medical doctors. So I never put effort to pass it … and apart, I simply switched off that subject in Grade 8 and 9... From primary, my dream career was (and still is) to be an accountant. I only realised in Grade 10 that for one to be an accountant, Mathematics is a requirement … but I cannot copy now. So it is not of choice to do Mathematics, but I found myself in that situation because of my career choice …"

- **In what way does the mathematics teacher help you during your preparation for end of term common tests?**

S21-24: "… They give us all the memoranda available. However, normally we don't do well in Mathematics, possibly because those who set the examination question papers at the circuit do not know what the teachers have taught in class … They assume that all the content has been covered according to 'their work schedule' …"

- **How do you use the mathematics memoranda during your preparation for the mathematics examinations?**

S1-4: "… I simply copy the answers (not the working) and fight hard to arrive at those answers … In fact it is like our basic textbook: it has answers only … So our task as students is to find out how the answer was arrived at …"

S21-24: "… The memorandum is not doing any good to us as students, because we tend to memorise the workings of questions in the memorandum, but it's not all … During examination time, it becomes difficult to attempt the questions …"

S29-32:"… Our teacher always makes sure he writes the memoranda of all written tests and examinations on the board as corrections, so that we can copy for our own revision … So, you know what, we normally memorise the memoranda when preparing for the examinations."

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4. TRANSCRIBED INTERVIEWS WITH CURRICULUM ADVISORS

- **What are the challenges, if any, of implementing reform practices brought about by the NCS in the teaching and learning of mathematics?**

A2: "… The challenges we face are to bridge the gap between the subject content knowledge and pedagogical content knowledge as demanded by NCS …"

- **How do you identify teachers' instructional strengths and weaknesses to inform professional development opportunities for them in the teaching and learning of mathematics?**

A1: "… We know some of the topics in the new NCS that were not part of the teacher training programme. However, we also go on the ground and ask them challenges they encounter, especially in subject content knowledge. All in all, we then workshop them on the identified problematic content area …"

- **What means are in place for helping teachers adapt their teaching practices to the increasingly diverse learning styles they find in their mathematics classrooms?**

A1: "… To help teachers adapt to the demands of NCS, we have common work schedules, assessment plans, tests, assignments, investigation and projects given to every school within the circuit … This is done to ensure uniformity in teaching and compliance with the LOs and assessment standards in Mathematics … It does not mean we do not trust teachers, but we are saying the NCS has new content and assessment styles that the current crop of teachers never did during their training …"

- **How do you ascertain that the actual teaching of the scheduled content per week, per term and per year is indeed done?**

A2: "… We ascertain by the assignments, end of term and year tests given to all our schools and have trust that the principal, the HoDs and the teachers work hand-in-hand to complete the schedules in time … But sometimes, if the HoDs or principals are not involved, it is not easy to ascertain …"

Appendix F: CHECKLIST OF DOCUMENTS

Please indicate the documents that are available for analysis with a tick (√).

	Available	Unavailable
• The school's vision and mission statement		
• Registers		
• Policy documents		
• Mathematics learning programme for senior and FET phases		
• School's annual assessment programme		
• Mathematics work schedules for senior and FET phases		
• Time-tables		
• Minutes of staff and departmental meetings		

Appendix G: LIST OF CATEGORIES

Category 1: The principals should manage the teaching and learning of mathematics in order to improve student performance.
• Overseeing the mathematics curriculum across the various grade-levels is lacking. • No evaluation of mathematics teachers' and students' work. • No mechanism put in place to ensure teachers are indeed teaching while in class. • No means of checking whether or not mathematics HoDs are monitoring the work of their subordinates. • A culture of the teaching and learning of mathematics is lacking. • No information meetings with parents about the importance of checking and forcing their children to do mathematics homework. • Students promoted without passing mathematics in Grades 8 and 9 for fear of shrinking enrolments due to exodus to other schools.

Category 2: The mathematics curriculum advisors need to support teachers in their endeavours to adapt to the NCS demands.
• No follow-up done to help teachers adapt NCS demands to the classroom situation. • Too much focus on the CASS marks for accountability. • No means of checking whether or not the principal or the mathematics HoDs are monitoring the work of the mathematics teachers. • Advisors not aware of the real mathematics classroom situation.

Category 3: The HoDs should lead the teaching and learning of mathematics through direct observation of teachers teaching and modelling good instructional practices.
• No modelling of good instructional practices in a classroom situation. • No follow-up done by HoDs to help teachers adapt NCS demands to their own situations. • No coordinating and focusing around the mathematics curriculum collectively by mathematics staff.

Category 4: The department of mathematics and science needs to revisit their teacher workshop development models.
• Lecturer-centered approach workshops. • Workshops characterised by handing out material and reading by presenters. • Workshops disconnected from classroom practices. • Workshops not influencing teacher practice and student achievement.

Category 5: Extra lessons provide the potential to compensate for the alleged poor preparation in previous grades or schools, and the problems arising from students being promoted through grades before they are ready.
• The SMT and SGB not willing to pay for extra lessons. • Parents not willing to hire private tutors to complement school programmes. • Parents not monitoring the performance of their children. • Parents not ensuring that their children do their homework.

Category 6: A mathematics classroom with 35 or fewer students enhances teacher-student interaction in the teaching and learning of mathematics.
• Peer-tutoring not practised. • Over-crowded mathematics classrooms hamper effective teaching and learning. • Teacher-student interaction in the teaching and learning of mathematics disabled.

Category 7: Encourage students who proceed to Grade 10 without the minimum required pass in Mathematics to do Mathematical Literacy instead.
• Weak students not encouraged to take up Mathematical Literacy. • Students electing Mathematics for prestige and then switch off. • The SMT and SGB not willing to pay for extra lessons. • Promoting students who don't pass Mathematics in Grade 9 for fear of shrinking enrolments due to drop-outs and exodus to other schools.

Category 8: Principals should observe a teacher once every term to inform professional development.
• Workshops confined to content knowledge only. • There is a gap between what is offered at the workshops and what is experienced in the classroom. • Pedagogical content knowledge not dealt with in the workshops.

Category 9: Team-teaching enhances the teaching and learning of mathematics.
• No sharing of lessons. • A culture of teaching and learning of mathematics is lacking.

Category 10: How-I-teach type workshops have the potential to empower the classroom teacher.
• Teachers told what to learn. • Teachers have no control over their own learning. • Workshops disconnected from classroom practices. • Workshops do not influence teacher practice and student achievement. • Workshop organisers not putting the whole burden on teachers to workshop themselves and comment on the contributions of other teachers.

Appendix H: LIST OF PATTERNS

Pattern 1: The principal's mechanisms for exercising control before teaching, during teaching and after the completion of work planned enhances the quality of the teaching and learning of mathematics.
• Principals should manage the teaching and learning of mathematics in order to improve student performance. • Extra lessons provide the potential to compensate for alleged poor preparation in previous grades or schools, and the problems arising from students being promoted through grades before they are ready. • Principals should observe a teacher teaching once every term to inform professional development. • HoDs should lead mathematics teaching and learning through direct observation of teachers teaching and modelling good instructional practices.

Pattern 2: Interactions among teachers, specific groups of students, colleagues at school, subject area committees, the curriculum and materials developed by others improve the quality of the teaching and learning of mathematics.
• Team-teaching enhances mathematics teaching and learning • Extra lessons provide the potential to compensate for alleged poor preparation in previous grades or schools, and the problems arising from students being promoted through grades before they are ready. • HoDs should lead mathematics teaching and learning through direct observation of teachers teaching and modelling good instructional practices. • Mathematics curriculum advisors need to support teachers in their endeavours to adapt to the demands of the NCS.

Pattern 3: A reciprocal process (an equal partnership) in which parents, teachers, the SMT and students shape the environment and support the learning endeavour through their thoughts and behaviours exert an influence on the teaching and learning of mathematics.
• Encourage students who proceed to Grade 10 without the minimum required pass in Mathematics to do Mathematical Literacy instead. • HoDs should lead mathematics teaching and learning through direct observation of teachers teaching and modelling good instructional practices. • Principals should manage the teaching and learning of mathematics in order to improve student performance. • Principals should observe a teacher once every term to inform professional development. • Team-teaching enhances mathematics teaching and learning.

Pattern 4: Competence in content, pedagogy and assessment in mathematics reflects a balance of the instructional practices of teachers that enhance both teaching and curriculum-based assessments of students' learning.
• HoDs should lead mathematics teaching and learning through direct observation of teachers teaching and modelling good instructional practices. • The department of mathematics and science needs to revisit its teacher workshop development models. • Principals should observe a teacher once every term to inform professional development. • Mathematics curriculum advisors need to support teachers in their endeavours to adapt to the demands of the NCS.

Pattern 5: The way students are distributed in classes and the promotional culture of the school makes a difference in students' performance in mathematics.
• Encourage students who proceed to Grade 10 without the minimum required pass in Mathematics to do Mathematical Literacy instead. • A mathematics classroom with 35 or fewer students enhances teacher-student interaction in mathematics teaching and learning. • Principals should manage mathematics teaching and learning in order to improve student performance.

Appendix I: EXTRACT FROM THE GRADE 12 MATHEMATICS WORK SCHEDULE FOR 2011

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF EDUCATION

GRADE 12

MATHEMATICS

WORK SCHEDULE

2011

Appendix I (continued)

TIME	LEARNING OUTCOMES AND ASSESSMENT STANDARDS	CONTENT	ASSESSMENT
Week 1-3	**LO2: Functions and Algebra**		
12-28 Jan	**As1:**		
2011	(a) Demonstrate the ability to work with	1. Study of functions	Daily
	various types of functions and relations	Formal definition of	informal
	including the inverses in the following	$y = ax + q$; $y = ax^2$;	assessment
	assessmentg standard.	$y = a$, $a>0$	/classwork
	(b) Demonstrate knowledge of the	2. Sketch graphs of	
	formal definition of a function.	the inverses of the function	
	As2:	above using the	
	(a) Investigate and generate graphs of	characteristics:	
	the inverses relations of functions, in		
	particular the inverses of:	(i) Domain and Range	**Investigation**
	$y = ax + q$; $y = ax^2$; $y = a$, $a>0$	(ii) Intercepts with axes	**/project**
	(b) Determine which inverses are	(iii) Turning points,	
	functions and how the domain of the	minima and maxima	
	original function needs to be restricted	(iv) Asymptotes	
	so that the inverse is also a function.	(v) Shape and symmetry	
		(vi) Average gradient	
	(c) Identify characteristics as listed below	(average rate of change)	
	and hence use the applicable	(vii) Intervals on which	
	characteristics to sketch graphs listed	the function increases	
	above.	/decreases.	
	(i) Domain and Range		
	(ii) Intercepts with axes		
	(iii) Turning points, minima and maxima		
	(iv) Asymptotes		
	(v) Shape and symmetry		**Short Test**
	(vi) Average gradient (average rate of		
	change)		
	(vii) Intervals on which the function		
	increases/decreases.		

Appendix I (continued)

TIME	LEARNING OUTCOMES AND ASSESSMENT STANDARDS	CONTENT	ASSESSMENT
Week 8-9	**LO3: Space, Shape and Measurement**		Daily
28 Feb-	**As3:** Use a 2-dimensional Cartesian	(a) The equation of a circle	informal
11-Mar	co-ordinate system to derive and apply:	(any centre)	assessment
2011	(a) The equation of a circle	(b) The equation of tangent	/classwork
	(any centre)	to a circle given a point on the	
	(b) The equation of tangent	circle.	
	to a circle given a point on the		
	circle.		
	Note: learners are expected to know and		
	be able to use as an axiom: "the tangent		
	to the circle is perpendicular to the		
	radius drawn to the point of contact".		
Week10-11	**LO3: Space, Shape and Measurement**		Daily
14-25 Mar	**As5:** Derive and use the following	Compound angle identities:	informal
2011	compound and double angle identities:	(a) sin $(\alpha \pm \beta)$	assessment
	(a) sin $(\alpha \pm \beta)$		/classwork
		(b) cos $(\alpha \pm \beta)$	
	(b) cos $(\alpha \pm \beta)$		
		Double angle identities:	
	(c) sin 2α	(c) sin 2α	**Controlled**
			(quarterly)
	(d) cos 2α	(d) cos 2α	**Test**
			17/03/2011
TERM 2			
Week 12-13	**LO3: Space, Shape and Measurement**		Daily
11-29 April	**As6:** Solve problems in two and three	Problems in two and three	informal
2011	dimensions by constructing and	dimensions	assessment
	interpreting geometric and		/classwork
	trigonometric models		
…	…	…	…