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The effect of instructional efficiency on grade 6 learners' mathematics achievement in Mpumalanga in the SACMEQ III.

by

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Submitted in partial fulfilment of the requirements for the degree

MAGISTER

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ABSTRACT

The effect of instructional efficiency on Grade 6 learners' mathematics achievement in Mpumalanga in the Southern African Consortium for Monitoring Education Quality (SACMEQ) III**.**

The aim of this study is to investigate the effect of instructional efficiency on Grade 6 learner achievement in Mathematics in Mpumalanga in SACMEQ project III. Since 1994, South Africa in pursuit of improvement in educational quality has had extensive curricular changes and increases in educational budgets. Furthermore, the country has participated in a number of national and international studies of learner achievement such as the systemic study, Southern African Consortium for Monitoring Education Quality (SACMEQ), Progress in International Literacy Study (PIRLS) and Trends in International Mathematics and Science Study (TIMSS). However, learner results across all the studies have been consistently low.

Mpumalanga learner results have been lower than that of other provinces such as Gauteng and their average score has been lower than the national average score. Mathematics achievement in particular has been very low. The study investigates the role that instructional strategies may have played in relationship to mathematics achievement.The conceptual framework is adapted from Slavin's (1995) model of effective instruction with key constructs being quality of instruction, appropriate level of instruction and time on task. The study follows a post positivist approach applying a correlational design. The population for this study is Mpumalanga Grade 6 learners.

The limitations of the study were that the data were collected about nine years prior, therefore some factors have changed, for instance Mpumalanga has its first University which offer teacher professional training. Secondly the SACMEQ III project removed variables addressing teaching and assessment in the classroom. These are items such as activities, goals and approaches used in mathematics. This reduced the element of continuity from one era to another and ability to make a comparison of the behaviour of such variables

The data was analysed applying descriptive statistics, correlational analysis, Principal Components Analysis and Hierarchical Multiple Regression analysis using SPSS. Mpumalanga data was analysed in comparison with Gauteng and South Africa overall. Since the main research question is about Mpumalanga, the factors affecting this province were addressed and then the differences and similarities were related to Gauteng and the nation.

The conclusions drawn from this study were that: English language proficiency and exposure has an effect on learner achievement in Gauteng and South Africa, Learners with educated parents have a higher likelihood of achieving better performance in Mathematics, teacher training has an effect on learner performance in Mpumalanga and South Africa, socioeconomic status is a predictor of learner achievement and classroom resources have an influence on performance in Mathematics.

Key words: Mathematics achievement, SACMEQ, Learner achievement, Instructional efficiency, Grade 6, Regression analysis.

DEDICATION

This dissertation is dedicated to the memory of my late brother Sefogole Frans Makgeru who passed away in 2014 when I was in the middle of the process of writing. He was a source of motivation for me both academically and in life generally. His love for writing and reading was beneficial to me as he read most of the chapters that I had already written before he passed away. Rest in peace *HLABIRWA 'A NGWATO*.

DECLARATION

I Ntepane Phillistas Makgeru

Student number: 29452733

Declares that the dissertation which I hereby submit for the degree MEd in Assessment and Quality Assurance at the University of Pretoria is my own work and has not been previously been submitted by me for a degree at this or any other tertiary institution.

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LIST OF ACRONYMS AND ABBREVIATIONS

ANA	Annual National Assessment
ASs	Assessment Standards
C2005	Curriculum 2005
CAPS	Curriculum and Assessment Policy Statement
DBE	Department of Basic Education
DoE	Department of Education
FET	Further Education and Training
FPL	Food Poverty Level
GDP	Gross Domestic Product
GET	General Education and Training
HDE	Higher Diploma in Education
HE	Higher Education and Training
HED	Higher Education Diploma
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
HSRC	Human Science Research Council
IEA	International Association for Evaluation of Educational Achievement
IIEP	International Institute of Educational Planning
KMO	Kaizer-Meyer-Olkin
LBPL	Lower Bound Poverty Level
LO	Learning Outcome
LoLT	Language of Learning and Teaching
MECs	Members of Executive Committees
NCS	National Curriculum Standard
NQF	National Qualification Framework
NSC	National Senior Certificate
OBE	Outcome Based Education
OECD	Organisation for Economic Cooperation and Development
PCA	Principal Component Analysis
PGCE	Post Graduate Certificate in Education
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment

PPS	Probability Proportional to Size
PTD	Primary Teachers Diploma
QAIT	Quality of instruction, Appropriate level of instruction, Incentives and Time
RNCS	Revised National Curriculum Statement
SA	South Africa
SACMEQ	Southern African Consortium for Monitoring Educational Quality
SE	Standard Error
SES	Socio-economic status
SPSS	Statistical Package for Social Sciences
STD	Secondary Teachers Diploma
TIMSS	Trends in International Mathematics and Science Study
UBPL	Upper Bound Poverty Level
UNESCO	United Nations' Educational, Scientific and Cultural Organisation
USA	United States of America

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CHAPTER 1

INTRODUCTION TO THE STUDY

1.1 INTRODUCTION

The aim of this study is to investigate the effect of instructional efficiency on Grade 6 Mathematics achievement in Mpumalanga in SACMEQ III. Since democratisation, and in pursuit of the improvement in educational quality, South Africa has undertaken a number of national assessments of learner achievement, such as the Grade 6 systemic evaluation (Department of Education (DoE), 2005), regional assessment of learner achievement, such as the Southern and Eastern Africa Consortium for Monitoring Education Quality (SACMEQ) project II (Moloi & Strauss, 2005), and international assessments of learner achievement such as the Trends in International Mathematics and Science Study (TIMSS) (Howie, 1999; Reddy, 2006). The value of such studies is to monitor the quality of education in a country, and to generate information that can be used in planning and policy decision-making and which subsequently results in improvement in teaching and learning (SACMEQ, 2010; TIMSS, 2008).

Although, nationally, learner achievement in Mathematics is low, the results of Mpumalanga province learners are of particular concern. For instance, in the SACMEQ projects this province's learners have often been lower than the national average performance (Moloi & Strauss, 2005), whilst in the exit level National Senior Certificate (NSC) examinations the performance has also been low. In the three years spanning 2009 to 2011, Mpumalanga Grade 12 learners' average pass rate was 57%, which is 10 percentage points lower than the average NSC pass rate (63%) for the same period (Department of Basic Education (DBE), 2010, 2012). The study is a secondary analysis of the SACMEQ III project that focuses on exploring effects of teacher instructional strategies on achievement in Grade 6 Mathematics for Mpumalanga. Secondary data analysis is "any further analysis of an existing dataset which presents interpretations, conclusions or knowledge additional to, or different from, those produced in the first report on the inquiry as a whole and its main results" (Hakim, 1982, p.1). According to Heaton (1998), secondary data

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analysis is part of a research design whereby existing data collected for use in a prior study is employed.

The SACMEQ is a regional quality assurance organisation which was initiated in collaboration with the United Nations' Educational, Scientific and Cultural Organisation (UNESCO) and International Institute of Educational Planning (IIEP). The mission of SACMEQ is to evaluate and compare the general conditions of schooling and the quality of basic education in Southern and Eastern Africa. In order to accomplish its mission the organisation conducts research studies to gather relevant information. Of the three studies completed to date, the first, SACMEQ I, was undertaken from 1995 to 1998; the second, SACMEQ II, from 2000 to 2004; and the third, SACMEQ III, from 2007 to 2011. Project I involved Grade 6 learners who wrote a test in English in all countries including South Africa except for Mozambique where the test was in portuguese. SACMEQ II and III tests were in Reading and Mathematics, with both learners and teachers participating. A further test on the knowledge of Human Immunodifficiency Virus /Acquired Immunodeficiency Syndrome (HIV/AIDS) was written by the learners and teachers in project III.

The number of countries participating in the projects were seven, 14 and 15 for projects I, II and III respectively. South Africa first participated in the SACMEQ II study. Policy makers designed the study with the aim of testing the learners to find out the level at which they performed, while for teachers the objective was to find out their proficiency levels in handling the subjects they taught. To obtain a full picture of the conditions of schooling, information on social background of both learners and teachers and schools was also gathered (SACMEQ, 2012).

1.2 PROBLEM STATEMENT

Education in South Africa was characterised by inequality in both quality and resource allocation during the apartheid era (Troup, 1979). The country's Gini coefficient index in 2011 was 65.0 (World Bank, 2015) which indicated that the income inequality was still very high. However, the post-apartheid South African government has claimed commitment to improving the quality of education, notably

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through curricular changes and increased expenditure. Educational spending represented an average of five percent of the country's gross domestic product for the period between 1994 and 2010 (National Treasury, 2011). Since 1994, the country's education policies changed from segregated curricula to Outcomes Based Education (OBE), to Curriculum 2005 (C2005) and to the Revised National Curriculum Statement (RNCS), with the aim of improving the quality of education (Pudi, 2006). Recently, there have been further curricular changes with the introduction of a Curriculum and Assessment Policy Statement (CAPS) aimed at improving the implementation of the curriculum by filling the gaps in the RNCS, reducing repetitions and clarifying where necessary (DBE, 2011).

Despite monetary commitment and the curricular changes shown by the country, learner performance in Mathematics has been consistently low, as evidenced by learner achievement in national assessments (DoE, 2003, 2005), regional assessment such as SACMEQ II (Moloi & Strauss, 2005) and international assessments such as the TIMSS (for example, Howie, 1999; Reddy et al., 2006). Nor has achievement been optimal in Grade 12 National Senior Certificate exit examinations, particularly for Mathematics, as reflected in the Mathematics mean pass rate for the period 2008 to 2011 of 46 %, compared to the overall average national pass rate of 65% for the same period (DBE, 2010; 2012). To compound the problem, the overall national pass rate might have been artificially boosted by Mathematics learners taking relatively 'easy' subjects such as Mathematical Literacy, which pushed up the overall mark (Spaull, 2013).

A national systemic evaluation study carried out by the DoE in 2005, of Grade 6 learners of Mathematics, Natural Sciences and the Language of Learning and Teaching (LoLT) found their achievement to be low. The aim of the systemic evaluation was to assess the effectiveness of the education system by determining the impact of policy and curricular changes made earlier. In the 2003 cycle of the systemic evaluation study, Grade 6 Mpumalanga learners scored an average mark of 15% in Mathematics, well below even the national mean score of 27% (DoE, 2003). In the 2005 cycle, the national Mathematics average score was again 27% (DoE, 2005), with Mpumalanga learners' achievement slightly lower at 25% (Kanjee, 2007). Although this apparent 10% increase in Mpumalanga learner

Mathematics average mark was significant, it was not clear if it marked an improvement in learning and teaching or some external reasons such as the quality of test items, administration, scoring or capturing. In the regional study SACMEQ project II conducted in 2000, the country's Grade 6 learners achieved a Mathematics mean score of 486 (Standard Error (SE) =7.2), which was lower than not only the SACMEQ mean score of 500, but also the mean scores of the majority of participating countries (Moloi & Strauss, 2005). This is in spite of South Africa having the highest expenditure on education. Other participating countries, such as Botswana and Uganda, achieved mean scores higher than 500, with learners of Botswana achieving on average 512 (3.15) (Keitheile & Mokubung, 2005), while their Ugandan counterparts attained a mean score of 517 (3.14) (Byamugisha & Ssenabulya, 2005). Although Botswana and Uganda achieved higher than South Africa, their average per capita expenditure on primary Education was far lower than that of South Africa. South Africa dedicated an average of 18% of total government expenditure to primary education while Botswana and Uganda spend 8% and 7% respectively (World Bank Group, 2012). Moreover, only 1% of South African participating learners could solve an abstract mathematical problem, indicating that their mathematical thinking skills were poor.

Not only did South African learners' perform below other African countries, but Mpumalanga learners performed well below other provinces. Mpumalanga learners, specifically, achieved a mean score of 433 (10.4), 53 points below the national mean, and about 90 points below Gauteng 's score of 522 (26) (Moloi & Strauss, 2005). For the SACMEQ III project, nationally, learners had an average score of 495 (3.8) for Mathematics, again below the SACMEQ average score of 500 (Hungi et al., 2010). The results indicated that there was a lack of improvement on learner mathematical skills and knowledge since SACMEQ II in 2000. The South African learners were ranked eighth out of 14 countries; behind countries such as Swaziland, Tanzania and Kenya, which are relatively poorer (Spaull, 2013).

In other international comparative studies of educational achievement, South African learners' achievement has also been disconcerting. The country participated in the International Association for the Evaluation of Educational Achievement's (IEA) TIMSS in 1999 and 2003, which involved the evaluation of Grades 4 and 8 learners in Mathematics and Science over four year cycles. In 2003, South African Grade 8 learners achieved an average score of 264 (5.5) in Mathematics (Reddy, 2006), which was not significantly different from that of the prior cycle in 1999, where the mean score was 275 (6.8) (Howie, 1999). In both cycles, the performance was below the international set average score of 500. All African countries participating in the study performed better than South Africa in Mathematics in both cycles, with, for example, Tunisia achieving a mean score of 448 (2.4) in 1999 (Mullis et al., 2000), and Egypt 406 (3.5) in 2003 (Mullis, Martin & Foy, 2005). In line with the lower national results, Mpumalanga learners' Mathematics achievement was an average score of 261 (10.6) in 2003, while in a cycle before the mean score had been 253 (15.2). As with the national and regional studies discussed above, Mpumalanga provincial results were lower than the national results in both cycles (Reddy, 2006).

Nor is this poor achievement confined to Mathematics. In the IEA's Progress in International Reading Literacy Study (PIRLS) for 2006, South African learners performed the worst of all the 40 participating countries. The study involved the assessment of Grade 4 learners' reading literacy. South Africa included Grade 5 learners as a national option due to the history of the country's poor achievement in other international studies of learner achievement, such as TIMSS 2003. The Grade 5 learners' mean score was 302 (5.6), considerably lower than the international set mean of 500, while the Grade 4 learner achievement results of a mean score of 253 (4.6) were not usable for comparative purposes as they were too low (Howie, Venter, van Staden, Zimmerman, Long, du Toit, Scherman & Archer, 2007). A major concern about poor language proficiency is its negative impact on learner performance in other subjects, including Mathematics. Learners tend to score highly in Mathematics when their proficiency in English which is the LoLT for most learners in secondary school is high. This was discovered during Howie's (2003) investigation of the effects of (English) language on South African learner performance in the TIMSS 2003 study.

In summary, the problem to be addressed in this study is that learner performance in Mathematics has been lower in Mpumalanga than nationally and other provinces

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such as Gauteng. This is in spite of changes in curricular and funding initiated by government since 1994.

1.3 RATIONALE FOR THE STUDY

The success of a country's economy depends on mathematics as it serves as the basis of other fields such as science, accounting and statistics. This is because technological innovations result in the economy producing as many kinds of products as possible and these innovations are under-pinned by knowledge and expertise in mathematical sciences (Department of Science and Technology, 2008). However, as outlined above, mathematical performance in South African schools has been low, and this cannot have helped the country achieve its full economic potential (Makgatho & Mji, 2006). Poor resourcing, poor teacher preparation and poor teaching practices are some of the reasons offered for poor mathematical achievement in South Africa (Howie, 2003; Louw, Muller & Tredoux, 2008), with pedagogical content knowledge also important in the process of learning and teaching.

Mathematical achievement can be affected by how well the teacher knows the content and how she/he plans the lesson and interacts with learners (Adedoyin, 2011). In their study in Germany, Lange, Kleickmann and Moller (2012) found out that pedagogical content knowledge has a significant relationship with learner achievement, as teachers who have good knowledge and understanding of the content can adapt and present it to suit the level of understanding and interest of their learners. This often results in learners achieving good results.

As a teacher in the province, I have a vested interest in Mpumalanga learners' performance in Mathematics. This has prompted a secondary analysis of the instructional strategies used by Mpumalanga teachers using questionnaire data for the SACMEQ III. The purpose of the secondary analysis is to investigate potential factors which may be contributing to the problem in Grade 6. This study may be important for:

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- educational authorities and policymakers who may become aware of the importance of good instructional strategies and offer in-service support to teachers for refining their skills;
- educational authorities who may take into consideration the characteristics of learners in to consideration when planning for curriculum implementation.
- school managers who may become aware of positive educational practices and encourage their teachers to try them ; and
- teachers who may become aware of new strategies of teaching and assessing learners and try these in their classes.

1.4 RESEARCH QUESTIONS

Against the above background and research problem, I pose one main research question and five sub-questions linked to it:
What is the effect of instructional efficiency on Grade 6 learners' Mathematics achievement in Mpumalanga in SACMEQ III?

To fully explore the main question, the following secondary questions are used:

Sub question 1: How did Mpumalanga learners perform in Mathematics in SACMEQ III and how did it compare to Gauteng and South Africa?

Sub question 2: What is the relationship between the characteristics of learners and their achievements in Mathematics?

Sub question 3: What is the relationship between Time on Task and learner achievement?

Sub question 4: What is the relationship between the quality of instruction and learner achievement?

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Sub question 5: What is the quality of instruction in Mpumalanga in relation to Gauteng and the overall South Africa and how does it affect Mathematics achievement?

The above research questions are answered by applying correlational analysis using Pearson's moment correlation analysis and hierarchical multiple regression analysis using Statistical Package for Social Sciences (SPSS). The correlational analysis is performed to find any association existed between teachers' instructional practices and mathematical achievement for the SACMEQ III data (Gay, Mills & Airasian, 2009). In addition, multiple regression analysis is conducted to see the interactions that may have existed between the dependent variable (mathematical achievement) and independent variable (instructional strategies) (Cohen, Manion & Morrison, 2007).

1.5 CONTEXT OF MPUMALANGA PRIMARY EDUCATION

This study took place in the context of Mpumalanga, one of South Africa's provinces. The country has a federal system of education, which means that some responsibilities are centralised, for example, curriculum formulation, while others are decentralised, such as curriculum implementation. This puts the provincial education department below the national department, and so the provincial department is mainly responsible for implementing the latter's policies. The structure of education in South Africa, curriculum reforms in South Africa from 1994 onwards (1.5.1), Mpumalanga socioeconomic–political context (1.5.2) and the impact of educational reforms in Mpumalanga (1.5.3) are described below.

1.5.1 Structure of education in South Africa

The National Department of Education is responsible for education and is subdivided into the Department of Basic Education (DBE) and Department of Higher Education and Training. The DBE is responsible for primary, adult and secondary education, while tertiary education falls under the Higher Education and Training Department.

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South Africa's education is divided into three levels, namely the General Education and Training (GET) band, the Further Education and Training (FET) band and Higher Education and Training band (HE). The GET is formed by Grades R to 9, which is subdivided into the Foundation phase (Grade R-3), the Intermediate phase (Grade 4-6) and Senior Phase (Grades 7-9) and the Adult Basic Education and Training, whereas the FET comprises of Grades 10 to 12. This study is based on the SACMEQ III project which focused on achievement of learners in Grade 6 Mathematics which is part of the intermediate phase. The Higher Education and Training band consists of all nationally recognised diplomas and certificates up to and including postgraduate degrees. (Human Science Research Council (HSRC), 1995). The three tiers of education are best explained under the National Qualifications Framework (NQF), as developed by the South African Qualification Authority (HSRC, 1995). The NQF is represented in Table 1.1.

Table 1.1: National Qualifications Framework.

NQF LEVEL	BAND	TYPE OF QUALIFICATION OR CERTIFICATION
8	HE	Doctorates Further research degrees
7		Higher degrees Higher diplomas
6		First degrees Higher diplomas
5		Diplomas Occupational Certificates
4	FET	School, College , Trade Certificates
3		School, College, Trade Certificates
2		School ,College, Trade Certificates
1	GET	Grade 9 (10 years of formal schooling) ABET level 4 Grade 7 (8 years of formal schooling) ABET level 3 Grade 5 (6 years of formal schooling) ABET level 2 Grade 3(4 years of formal schooling) ABET level 1

Source: HSRC (1995)

1.5.2 Curriculum reforms in South Africa from 1994 onwards

The introduction of democracy in 1994 brought many changes, one of which was in the sphere of education. The previous 19 Education Departments, segregated according to race and language, were amalgamated into one (Jansen & Taylor, 2003). The OBE system of education, known as C2005, was adopted in 1997 and further modified in 2002 as the RNCS. Both centred on the learner and followed a theory that all learners are capable of learning, although at different paces (Jansen & Taylor, 2003). In 2012, a further change in curriculum was made, resulting in an NCS (R -12), which included Curriculum Assessment Policy Statements. The three curricula are described in the next sub-sections.

1.5.2.1 Curriculum 2005 (1997 to 2001)

The OBE curriculum model, C2005, focused on what the learner should know, understand, demonstrate and become at the end of the learning and teaching process (Mouton, Louw & Strydom, 2012). Additionally, the curriculum regarded continuous formative assessment as the main form of assessment, in contrast with the apartheid curriculum which was teacher-centred, content-based and summative assessment-based (Jansen & Taylor, 2003).

The curriculum was based on eight critical and cross-field outcomes and 66 specific outcomes, which indicated the desirable knowledge, skills and values for learning (Jansen & Taylor, 2003). The traditional subjects were substituted with eight Learning Areas of Arts and Culture, Technology, Language, Literacy and Communication, Physical and Natural Sciences, Economic and Management Sciences, Human Social Sciences, Mathematical literacy, Mathematics and Mathematical Science and Life Orientation (Jansen & Taylor, 2003). The curriculum for the Foundation Phase consisted of three Learning Areas, namely: Literacy Skills (Basic reading and writing), Numeracy (Basic Mathematics) and Life Skills while in Grades 4-6 Mathematics and Languages were introduced in the place of Numeracy and Literacy. From Grade 4 the learner did all the eight learning areas (DoE, 2002a). The curriculum emphasised integration between and within learning areas, as such its focus was more on the process of instruction (Jansen & Taylor, 2003).

The implementation of the C2005 did not meet the expectation of the DoE, as it was confusing for most teachers due to the complexities of the language used (DoE, 2002 a). Jansen (1998) had already predicted that the difficult language used in the curriculum would make it inaccessible to many teachers. He indicated that for teachers to understand the concept 'outcome', they would need to understand 50 other concepts which included competencies, assessment standard, range statement and learning programme. Furthermore, he foretold that the situation would be worsened by the lack of access to curriculum information by many teachers or lack of full understanding in instances when the information was available. Another factor which he anticipated as having a negative impact on the implementation of the curriculum was the uneven, fragmented and often non-existent support from the educational officials to teachers (Jansen, 1998). All of these predictions turned into reality a few years after the commencement of the implementation of C2005.

Another disadvantage of the curriculum was that it did not specify the content which should be taught to achieve the outcomes, therefore it was left to teachers to interpret and decide on suitable content and context to address outcomes (Mokhaba, 2005). This had the potential to result in different schools teaching conflicting content to address the same outcomes (Jansen, 1998). Moreover, Jansen and Taylor (2003, p.39) argue that the curriculum favoured process at the expense of content and was strong on horizontal integration which involved amalgamation of various parts of it, whilst being vague on vertical integration which entails the content demands for progression of the learner to another grade.

On the other hand, C2005 increased the administrative duties of teachers. Assessment had to be continuous and developmental, thus the aim was to find what outcomes had been achieved by learners and find ways to help them improve on aspects in which they were lacking. This required that the teacher spend time monitoring the individual learners' progress and giving multitudes of opportunities to them to achieve the outcome (Mokhaba, 2005). Given the complexities of the outcomes-based assessment tasks, many teachers could not formulate them; hence they continued using traditional tasks (Jansen, 1998). One other factor for the unsuccessful implementation of C2005 was that many schools still had poor

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resources. OBE needed schools that were well-resourced in terms of qualified staff and material resources, such as classroom, furniture, equipment and textbooks, but this was not the case in South Africa (Zimmerman, 2010). Jansen and Taylor (2003) found that C2005 had the potential to aggravate the inequalities between the poorly and the well-resourced schools:

> *… "the under specification of the curriculum content and the priority given to integration was likely to lead to the submergence of conceptual knowledge in the everyday, and well-resourced schools were more likely to implement the curriculum as intended than teachers in poor schools. C2005 could therefore result in exacerbation of existing inequalities in terms of access to high level conceptual knowledge" (p.38).*

In 2000, a Review Committee appointed by the DoE to investigate how the C2005 had been implemented found that the curriculum was problematic and recommended that:

- it be streamlined and its language simplified;
- there be an improvement in supply of learning material;
- there be an improvement in provincial curriculum support to schools;
- there be improvement in teacher training in regard to the curriculum; and
- the pace of implementation be reduced (DoE, 2002a).

1.5.2.2 Revised National Curriculum Statement (RNCS) (2002 to 2011)

In implementing the recommendation of the Review Committee, the restructured version of the C2005 was created and called RNCS in Grades R to 9, while it was (in later years) known as the National Curriculum Statement (NCS) in the FET band. In 2007, when the SACMEQ III study was undertaken, this was the curriculum that was followed. The basis of the curriculum was the Critical Outcomes (Cos) which, however, had been decreased from eight to seven and the Developmental Outcomes (DOs) which were five in number. The COs and the DOs were derived from the South African Constitution and described the sort of citizen the Education

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system strived to create through the curriculum (DoE, 2002b). The Critical Outcomes predicted a learner who would be able to:

- “identify and solve problems creatively and through critical thinking skills;
- communicate effectively using visual, mathematical and language skills, either orally or in writing;
- organise and manage themselves and their activities effectively and responsibly;
- collect, analyse, organise and critically evaluate information;
- understand that the world is a set of related systems and those problem solving contexts do not exist in isolation;
- use science and technology effectively and critically showing responsibility towards the environment and the health of others;
- work effectively with others as members of a team, group, organisation and community” (DoE, 2002b, p.1).

“The Developmental Outcomes envisioned a learner who had the ability to:

- reflect on and explore a variety of strategies to learn more effectively;
- participate as a responsible citizen in the life of local, national and global communities;
- be culturally aesthetically sensitive across a range of social contexts;
- explore education and career opportunities;
- develop entrepreneurial opportunities” (DoE, 2002b, p.1).

The main difference between the two curricula was that the RNCS, unlike its predecessor C2005, provided teachers with guidelines as to what content to teach to achieve a particular Learning Outcome (LO). Thus, C2005 lacked learning area specific Assessment Standards (ASs) on which teaching could be based and assessment monitored while the RNCS provides LOs, ASs and an outline of context and content to be covered (Beets & Le Grange, 2005).

The eight learning areas introduced under C2005 remained unchanged. For Mathematics, which was defined as a “human activity involving observing, representing and investigating patterns as well as relationships in physical and

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social phenomena" (DoE, 2002b, p.4), a learner who achieved mathematical knowledge, skills and values would be able to:

- "participate equitably and meaningfully (with awareness of rights) in political, social, environmental and economic activities by being mathematically literate;
- contribute responsibly to the construction and development of society by using mathematical tools to expose inequality and assess environmental problems and risks;
- display critical and insightful reasoning and interpretative and communicative skills when dealing with mathematical and contextualised problems;
- describe suitable situations using mathematical notations and language;
- apply mathematics in a variety of contexts;
- transfer mathematical knowledge and skills between learning areas and within mathematics;
- display mental algorithmic and technological confidence and accuracy in :
    - working with numbers, data, space and shape;
    - investigating patterns and relationships;
    - problem solving;
    - constructing new insights and meanings" (DoE, 2002b, p.5).

The mathematical knowledge, skills and values that a learner was expected to have gained at the end of the process of instruction were conveyed by the LOs. Grade 6 Mathematics learning area consists of five Los, as shown in Table 1.2.

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Table 1.2: Grade 6 Mathematics Learning Outcomes

LO 1: Numbers, operations and relationships

The learner will be able to recognise, describe and represent numbers and their relationships and to count, estimate, calculate and check with competence and confidence in solving problems.

LO 2: Patterns, functions and algebra

The learner will be able to recognise, describe and represent patterns and relationships as well as solve problems using algebra language and skill

LO 3: Space and shape (geometry)

The learner will be able to describe and represent characteristics and relationships between two dimensional shapes and three dimensional objects in a variety of orientations and positions.

LO 4: Measurement

The learner will be able to use appropriate measuring units, instruments and formulae in a variety of contexts.

LO 5: Data handling

The learner will be able to collect, summarise, display and critically analyse data in order to draw conclusions and make predictions and to interpret and determine chance variation.

Source: DoE (2002b, p.40-56)

To achieve the LOs teachers needed to engage learners in the process of instruction for a minimum of specified amount of time, thus also ensuring that they were sufficiently guided. In the Intermediate phase (Grade 6) this amounts to 18% of the official contact time of 35 hours per week. To know whether a learner had achieved the outcomes, assessment had to be applied. Assessment in the RNCS was linked with instruction and guided by the Assessment Standards (ASs), which were described as the level at which learners ought to demonstrate their achievement of LOs and the depth and width of doing so. ASs represented the knowledge, values and skills necessary to achieve the LOs (DoE, 2002b).

1.5.2.3 National Curriculum Statements (NCS) (R-12) (2012 to date)

The RNCS was further revised in 2012 with the introduction of the NCS (R-.12), which was a policy statement that directed teaching and learning in South African schools. The aim of the revised curriculum was to update the RNCS by cutting out repetition, aimed at improving on achievement. Changes included reduction of administrative duties of teachers, such as having a single teacher file rather than two as required by the RNCS, reduction in subjects from eight to six in Grades 4 to 6 and the introduction of additional language in Grade 1 (Mouton, Louw & Strydom, 2012). The NCS (R-12) comprised a Curriculum Assessment Policy Statement (CAPS), which prescribed what had to be taught. Every subject was to have its CAPS document. The National Policy pertaining to Programme and Promotion requirements document described the number of subjects in each grade and the requirements for a learner to progress to another grade. The National Protocol for Assessment document describes the standardisation of the recording and reporting process (DBE, 2015a).

1.5.3 Mpumalanga socioeconomic - political context

Mpumalanga is South Africa's smallest province in terms of geographical size, at 7,949 kilometres that constitute 6% of the country's land surface. It has a population of over four million, the majority (about 60%) of whom live in rural areas (Statistics South Africa, 2012). It has a legislative government headed by a premier, consisting of a cabinet formed by Members of Executive Committees (MECs), who head various provincial departments, one of which is Education (Jansen & Taylor, 2003). More than 52% of households in this province live in poverty. Statistics South Africa (2014) established that poverty takes place at three levels, namely: Food Poverty Level (FPL), Lower Bound Povery Level (LBPL) and Upper Bound Poverty Level (UBPL). FPL involves a situation where an individual is unable to afford sufficient food for adequate nourishment, LBPL is when individuals can afford to buy food but non-food items while UBPL is a situation where individuals can merely afford both food and non-food items. There is an apparent relationship between poverty and education as more than 78% of those who are poor have no education. Income can also be a good measure of the level of poverty. The province had one of lowest average annual incomes in the country (Statistics South Africa, 2014).

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1.5.4 The impact of education reform in Mpumalanga

The Mpumalanga Education Department has a political head in MEC, with four Districts, within each of which are circuits which serve as a link between schools and districts (Jansen & Taylor, 2003). The four education districts in Mpumalanga are Bohlabela, Ehanzeni, Gert Sibande and Nkangala. All learners of between seven and 15 years of age are by law expected to be in school, and in Mpumalanga the number of learners in primary school has been steadily growing. For example, the total enrolment in primary schools has increased from 809,292 in 2010 to 825,735 in 2013. In 2013, 77,582 of the 825,735 learners were in Grade 6, which represented about nine percent of all primary school learners. Since 2011, primary school learners (with the exception of Grade 7 and 8) have been undertaking the Annual National Assessment (ANA) which is a standardised national assessment in English and Mathematics. The purpose of the assessment is to measure the quality of teaching and learning as well as diagnose performance problems. The test question papers are supplied by the Department of Basic Education via the provincial education department. Schools manage the conduct, marking and moderation of the tests (DBE, 2015b). The results of the tests have been poor for Mpumalanga since their conception (Mpumalanga Education Department, 2014). The average provincial results for Grade 6 Mathematics have been under 37%. Additionally, similar to international studies, Mpumalanga learner performance has been below the national and other provincial performances. In 2013 the province learner performance was ranked 5th position for Grade 3, seventh position for Grade 6 and sixth position in Grade 9.

Table 1.3 (below) shows the performance of Mpumalanga's four districts in the ANA for 2012 and 2013 Mathematics test.

Table 1.3: Percentage pass in 2012 and 2013 Grade 6 ANA Mathematics

Year	Bohlabela	Ehlanzeni	Gert Sibande	Nkangala
2012	20	24	24	25
2013	29	34	34	36

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The achievement of learners was low across all the four districts in both 2012 and 2013. At a mean of less than 37% much improvement in learner performance was still necessary across all the districts especially in Bohlabela where learners achieved the lowest results compared to the other districts (Mpumalanga Education Department, 2014).

1.6 TERMINOLOGY USED FOR THE STUDY

It is important to define the key terms to facilitate an understanding of how they are employed throughout the dissertation. Some of the terminology has already been explained in the preceding sections, e.g., SACMEQ III. Below is the description of the remainder of the terms used in the study.

1.6.1 Instructional efficiency

Instructional efficiency is the level of performance achieved per minute of total Instructional time (Nist & Joseph, 2008). It has important implications for practitioners who often must operate under instructional and curricular time constraint (Nist & Joseph, 2008). In this study, it refers to the relationship between learner mathematics score and teaching and learning factors. Instructional factors include effort by the teacher and learner; time spent and cost involved carrying out the instructional process.

1.6.2 Mathematics achievement

Mathematics achievement as utilised in SACMEQ, involves learners' attainment of one of the skill levels tested in Mathematics. Those levels are *pre numeracy*, which involves application of single step addition or subtraction; *emergent numeracy*, involving two-step addition and subtraction; the third level is *beginning numeracy* which involves translation of verbal or graphic information into simple arithmetical problems. The fourth level is *basic numeracy*, which is concerned with translating verbal or graphical information into simple arithmetic problems. *Competency numeracy* is concerned with solving multiple operations and problems, and it comes before *mathematically skilled* and concrete problem solving skill. *Abstract problem*

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solving skills is the highest and it involves the extraction and conversion of information in order to solve multiple steps (Moloi & Strauss, 2005). In this study the same description is maintained.

1.7 CHAPTER DELINEATION FOR THE STUDY

Chapter 1 has introduced the study by presenting the background information and aims, with problem statement, rationale and research questions. The key terms employed in the study were explained to facilitate an understanding of how they have been used.

Chapter 2 consists of a review of research literature on the topic of instructional efficiency and mathematics achievement. The review covers international as well as national studies. It culminates in the conceptual framework for the study.

In Chapter 3 first the design and methods used in SACMEQ study are summarised. Thereafter the research design and methodology used in the study are outlined.

Chapter 4 presents the results derived from analysing the relationship between instructional efficiency and Grade 6 mathematics achievements in Mpumalanga, Gauteng and the overall South Africa as undertaken using descriptive and correlational analysis.

Chapter 5 describes analysis of instructional efficiency and Grade 6 mathematics achievement as undertaken using hierarchical multiple regression.

Chapter 6 presents a summary of the research process, summary of the research findings, reflection on methodology, reflection on conceptual framework, main conclusions drawn from the study, recommendations for research, policy and practice.

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CHAPTER 2:

THE LITERATURE REVIEW

2.1 INTRODUCTON

This chapter reviews relevant literature on the effect of instructional efficiency on learners' mathematics achievement. It addresses the SACMEQ variables that formed the core of the learner and teacher instructional questionnaire for project III and the four elements of the instructional efficiency model adapted from Slavin's (1995) QAIT model used in the conceptual framework. Relevant variables identified from SACMEQ III variables are: a variety of formal and informal assessments, allocated teaching time, engaged time and learner characteristics, whilst the elements of the QAIT model are quality of instruction, appropriate level of instruction, time and incentive to learn. As indicated in Chapter 1, for this study the term " instructional efficiency" refers to *the ratio between learner mathematics achievement and teaching and learning factors*, explored here from international and South African perspectives.

2.2 INTERNATIONAL STUDIES OF LEARNER ACHIEVEMENT

This section reviews international literature on the subject of instructional factors in mathematics classrooms. The discussion is guided by the variables of Slavin's (1995) QAIT model which is the conceptual framework for this study. The variables are: incentive to learn, quality of instruction, appropriate level of instruction and time on task.

2.2.1 Teaching strategy and mathematical achievement

A number of international researchers (see Siegel & McCoach, 2007; Burnett & Mandel, 2010) have conducted studies on the influence of instructional practices on mathematical achievement, however, the findings differ. The findings of those studies are described below.

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2.2.1.1 Incentive to learn

Certain strategies can be used for encouraging learners to achieve their best in mathematics (for example, Crow & Small, 2011)

Self - efficacy instructional strategy and mathematical achievement

Self-belief in one's own abilities can have an impact on academic achievement (Bandura, 1997) as teachers influence positively their learners' mathematical achievement by using a self-efficacy instructional technique. This technique involves verbal persuasion of learners, positive feedback (and praise), modelling which involves a learner watching others successfully performing learning tasks, and group work which provides learners an opportunity to work with peers (Siegel & McCoach, 2007). According to Burnett and Mandel (2010), praise and feedback is not a blanket strategy, but rather its success depends on factors such as age of the learner and the reason for the praise. In their study in Australia, Burnett and Mandel (2010) found that young learners (Grades 1 and 2) preferred to be praised for their ability, whilst older learners (from Grade 3 onwards) preferred to be praised for effort but in private rather than in front of the whole class. The younger learners did not mind being praised in the presence of others.

Similarly, motivation plays a vital role in learning as it serves as the driving force behind the learning process. Mart (2011) is of the opinion that motivation links positively with incentives such as praise, rewards, feedback from the teacher and the teacher's skill of organising the instructional material. Crow and Small (2011) report that positive informational feedback can increase learners' feelings of competency in educational activities, provided that the information is not being perceived as controlling. They also point out that incentives such as rewards have to be relevant to the learning behaviour that is being rewarded. If inappropriate, rewards often result in temporary motivation as learners tend to engage in learning for the sake of obtaining the rewards. Burnett and Mandel (2010) and Crow and Small (2011) regard praise as an incentive strategy which is misused regularly, because teachers often praise ability, which tends to discourage internal motivation.

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Learning environments in which learners are encouraged to be active, communicate their ideas and substantiate their reasons for the ideas, frequently result in increased motivation to learn, in turn increasing performance (Mueller, Yankelewitz & Maher 2011). The secondary analysis of the TIMSS 2003 Grade 8 mathematics data of five East Asian countries (Singapore, Japan, South Korea, Hong Kong and Chinese-Taipei) and four western countries (Australia, United States of America (USA), England and Netherlands) indicated that pleasure-oriented motivation had a major impact on achievement as opposed to productivity oriented motivation (extrinsic). East Asian learners were found to have been both intrinsically and extrinsically motivated, as opposed to their Western counterparts who had more external motivation. Thus, while the East Asian learners knew and liked the external rewards of doing mathematics they had a high internal appreciation and enjoyment for learning the subject (Zhu & Leung, 2010). This corresponds with the findings of a study involving Indian adolescents undertaken in India and Canada by Areepattamannil, Freeman and Klinger (2011,) which also revealed that internal learning goals have a greater link to improved educational outcomes. The immigrant Indian learners in Canada were found to be high in internal motivation and their performance tended to be significantly higher than counterparts in India. The findings indicated that teachers in Canada frequently made use of teaching strategies which encouraged learner autonomy (Areepattamannil, Freeman & Klinger, 2011).

2.2.1.2 Quality of instruction

Various strategies which are discussed below can have an influence on the quality of instruction offered in the classroom (for example, Kim, 2005; Rapp, 2009).

Traditional versus cooperative learning strategy and mathematical achievement

While group work is regarded as vital in increasing self-belief and academic performance, a study in China by Messier (2005) indicated that cooperative learning which involved group work did not increase learner performance, but rather a traditional approach which emphasised acquisition of knowledge and individual

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work yielded higher academic performance. In contrast, a study in Korea found that a constructivist approach (which also involved group work) had a more positive impact on mathematical achievement than a traditional teaching approach. This Korean study involved two groups of Grade 6 learners in a quasi-experiment, with the curriculum in the constructivist class presented in a way that allowed learners to think, create meaning, communicate and engage in group work while in the traditional approach class the focus was on basic skill and memorisation of so-called facts (Kim, 2005).

On the other hand, the findings of an exploratory study by Buschang, Chung and Kim (2011) indicated that group work cannot always result in overall improvement in learner performance. It involved middle school students in California, USA in which the experimental group consisted of pairs of learners of homogenous ability in mathematics (as determined by the pre-test) and some experience in playing video games (as self-reported by the learners). The experiment involved the paired learners playing mathematical video games collaboratively (group work) on one computer. Meanwhile, the control group consisted of learners who played the mathematical video game individually (traditional approach), covering topics such as numerator, denominator, addition of fraction and the concept of unit. The post-test results indicated that cooperative learning had affected the performance of learners of various abilities differently. Learners with lower pre-test scores recorded a greater improvement in performance after collaboration than when working individually, while learners with higher mathematical ability improved their scores more when working individually than when doing so collaboratively (Buschang, Chung & Kim, 2011).

Teaching strategies influence the learning of Mathematics in various countries differently. For instance, whilst group work (cooperative learning) has been found to be the cause of an increment in learner performance in Korea (Kim, 2005), House and Telese's (2008) analysis of the Grade 8 TIMSS 2003 data of achievement of Japanese and American learners found that the strategy of cooperative learning did not have a positive effect on learner outcomes in algebra. Learners who reportedly had been learning to work on mathematical problems on their own tended to score highly.

As part of constructivist strategy, research into collaboration between three junior high school mathematics teachers in Chicago, USA, showed that it had not positively influenced learners' mathematical attainment. The only discernible change was learner attitude towards the subject (Di Fatta, Gorman & Garcia, 2009). Ziegler and Yan (2001), in a study in a junior secondary school in Seattle, USA found that collaborative teaching had a strong relationship with mathematical achievement; however, the strength of the relationship was dependent on the experience and the gender of the teacher. Teachers with less than ten years of experience and females were more inclined to use and succeed in collaborating with their counterparts in teaching than their more experienced and male colleagues.

Learner-centred versus teacher-centred strategy and mathematical achievement

As with Siegel and McCoach (2007), Brown (2009) emphasises the strategy of encouraging self-efficacy and further states that presentation of the curriculum in a coherent sequence is important for an improved achievement. She advocates the use of both teacher-centred and learner-centred approaches in mathematics teaching. Moreover, in a study of junior primary school learners, Rapp (2009) emphasises that the learner-centred strategies should accommodate both the visual spatial learner and the auditory sequential learner. The visual learner primarily thinks in pictures and learns by seeing rather than by thinking, while the sequential learner is good in memorisation and thinking. Therefore, the visual learner should be afforded the opportunity to do mathematics in other ways, for example drawing, hands-on projects and games (Rapp, 2009). This is in alignment with Abdalla's (2008) report on multiple intelligences, in that everyone is capable of learning, however, no one way of learning can cater for all individuals as people tend to process information differently. Abdalla's (2008) report was based on Gardner's (2000) theory of multiple intelligences, which posits that people can be gifted in linguistic, logical mathematical, spatial, body-kinaesthetic, musical, intrapersonal, interpersonal and naturalistic ways.

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Abdalla (2008) explains that a multiple intelligence teaching strategy enables learners to express their understanding of subject matter in different ways. The effectiveness of a multiple intelligence teaching strategy was proven by the result of a study involving Grade 8 mathematics learners in Utah, USA (Douglas, Burton & Reese-Durham, 2008), who were taught using a multiple intelligence strategy showed a considerable improvement in performance after engaging in various learning activities. These activities included completing logical problems, constructing mathematical models, board games to illustrate learned materials, providing feedback on what learners would like to learn and performing a lesson presentation using at least one of the intelligences (Douglas, Burton & Reese-Durham, 2008). This concurs with the conclusion in Keat and Wilburne's (2009) study in Pennsylvania, USA, which found other ways of teaching mathematics, for example using story books to help kindergarten learners solve characters' problems, some of which required mathematical thinking skills.

Technology-based instructional strategy and mathematical achievement

The use of technology in the process of teaching and learning mathematics is widespread and can bring positive results, irrespective of the level of learners (see Weiss, Kramarski & Talis, 2006; Serin, 2011; Hudson, Kadan, Lavin & Vasquez, 2010). In Israel, a research study was conducted among kindergarten learners (4 to 7 year olds) who were divided into experimental groups and a control group. The former were taught using multimedia and the latter without. As indicated by the post-intervention test results, learners in the experimental groups showed greater improvement in their mathematical higher order skills, such as estimating, subtracting and adding (Weiss, Kramarski & Talis, 2006). Similarly, in Turkey the findings of a study among fourth grade learners (Serin, 2011) indicated that technology can have a positive impact on mathematical achievement. The experimental group received a computer-based instruction with emphasis on problem-solving while the control group received tuition without the use of computers. At the end of the quasi-experiment the problem-solving skills of the learners taught with the use of computers had improved greatly in comparison with the learners in the control group, who had received the traditional lesson on problem-solving (Serin, 2011).

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In Chicago, USA, the findings of an action research study conducted by Hudson et al. (2010) among learners in the fourth, fifth, sixth and ninth grades were similar to those of the Israeli (Weiss, Kramarski & Talis, 2006) and Turkish studies, with learners recording improvement in mathematical achievement after being taught using technology. The researchers administered a pre-intervention test to determine the initial performance of learners, after which learners were instructed on various mathematical topics, including fractions, percentages, decimals, subtraction and addition using various technological devices, mainly calculators and computers. The post-intervention results showed a significant increase in the scores over the pre-intervention results (Hudson et al., 2010).

The use of computers in the teaching and learning of mathematics resulted in no improvement in learner performance in Colorado, USA. Learners in Grade 9 received algebra tuition via the traditional method of instruction for the first part of the lesson and a computer assisted instruction programme *ASCEND* during the second part, focussing on individualised instruction which included video instruction. The end-of-year results revealed that the strategy had failed to improve mathematical performance. Another technology-based strategy that seemed to have an influence on learner achievement was reported in Japan, where those learners who regularly practiced mathematics without the usage of calculator achieved higher scores in algebra, whereas their USA counterparts who tended to practice mathematics making use of calculator performed poorly in the TIMSS 2003 algebra assessment task (House & Telese, 2008).

Constructivist teaching versus traditional instruction and maths achievement

While mathematics learning can be generally difficult for some learners (see Graham, Bellert & Pegg, 2007), for others, it tends to be harder when it comes to the learning of negative numbers (Altiparmak & Ozdogan, 2010). The confusion has often been about the naming of the arithmetic operation, the direction of the number as well as the meaning of the minus sign before the number. The findings of a quasi-experimental study undertaken in Turkey among sixth Grade learners (Altiparmak & Ozdogan, 2010) indicated that negative numbers can be successfully learned. The experimental group received an instruction supported by animations

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with a constructivist basis, while the comparison group received the traditional lesson on negative numbers in which they learned them without relating them to reality. The mathematical models in the animation presented to the learners by the teacher were transformed into mathematical language by learners themselves, thus, by using animation of events found in their environment the learners could construct knowledge on negative numbers effectively. The post-test results indicated a considerable difference in achievement on negative numbers in favour of the experimental group, whereas the pre-test results had indicated no real difference between the two groups (Altiparmak & Ozdogan, 2010).

Another success of constructivist teaching over traditional teaching was indicated by the results of a study conducted by Ilyas, Rawat, Bhatti and Malik (2013) in Sindh, Pakistan. The study was a quasi-experiment involving Grade 7 mathematics learners, aiming to find out the effect of teaching algebra through a constructivist approach. The treatment group was taught using a social constructivist approach which incorporated three parts of initiative learning (modelling), instructed learning (scaffolding) and construction of knowledge. In the initiative learning, the teacher gave a presentation about the topic, explaining how to solve the mathematical problem concerned. The instructed learning included a step-by-step presentation which included two-way discussion and use of various teaching aids. The last step involved collaboration between learners, who were divided into smaller groups and brainstormed over a solution to a mathematical problem. The control group were taught using a traditional method in which the teacher presented the solution to the problem using the lecture method. The teacher was largely the main participant in the lesson, with learners listening. The only learner involvement was when the teacher asked an occasional question that required a 'yes' or 'no' answer. The post-test results of the treatment group were higher than those of the control group (Ilyas, Rawat, Bhatti & Malik, 2013).

2.2.1.3 Time on task

Many studies in relation to time on task have been undertaken and the results show different influence of increase in instructional time on learner performance (see, Peter 2004, Calhoun, 2011).

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Increase in instructional time and mathematical achievement

While Brown (2009) advocates a good presentation of the learning matter for the learner to perform well, she also accentuates that time on task is important. For Peters (2004) this had an influence on learner attainment and linked positively with motivation and interest in participation in learning activities. Nonetheless, time on task is not a uniform strategy, as indicated by the results of the study undertaken in the South Central Region of the USA among Grade five learners of Hispanic origin for whom English was not their home language, and who came from a disadvantaged social background. Rivera and Waxman (2011) found that those learners who were mentally stronger than their circumstances tended to spend more time engaged in learning activities after school hours. They frequently attained improved results in mathematics while their non-resilient counterparts often engaged in little or no extra school activities and obtained poor results. Therefore, the success of time on task as a teaching strategy is dependent on the characteristics of individual learners (Rivera & Waxman, 2011).

Battistin and Meroni (2013) are also of the opinion that characteristics of learners play a role in the extent to which learner performance can improve after increase in instruction time. While Rivera and Waxman's (2011) study was in regard to learner engagement time, they concentrated on the allocated instructional time in a survey trend study in Southern Italy involving a cohort of learners from Grade 6 until Grade 8. The learners' Grade 5 end-of-the-year results were used for admitting the learners to the intervention programme. Coming from various socio-economic backgrounds they were provided with extended tuition using a variety of activities. The subsequent results indicated a greater improvement in performance of learners with low socio-economic background. However, the increase was not in basic mathematical knowledge but in the way it was acquired during school hours. In Canada, Noonan (2007) looked for a relationship between increased instructional time and achievements in mathematics. The study was a secondary analysis of the data for the 10 Canadian provinces which participated in the 2003 Programme for International Student Assessment (PISA), a programme run by the Organisation for Economic and Cooperation and Development (OECD). The study involved 15 year old (Grade 8) mathematics learners in ten provinces with different lengths of instructional time as decisions regarding educational matters were the responsibilities of each. The results indicated that there was weak positive correlation (0.09) between length of instructional time and mathematical achievement. Noonan (2007) explains that increasing allocated time without parallel increase in the quality of teaching often fails to improve learner performance. This concurs with Lavy‘s (2010) view that the improvement of learner performance after an increase in instructional time is dependent on productivity of such instructional time, which is also a by-product of a variety of factors, such as resources and teacher qualifications and skills. He conducted a secondary analysis of the data of all 50 countries that participated in the PISA 2006 mathematics to see if additional instructional time could have an influence on achievement. It was found that increased allocated instructional time had a positive influence on learner scores, however, the extent of the influence depended on the level of economic development of a country. Developing countries benefited less from additional tuition time than did their developed counterparts, due to their low instructional productivity.

On the other hand, the time on task strategy was proven to be unsuccessful when applied during tuition time. In Colorado, USA, Calhoun (2011) conducted a study to find out if a time on task intervention could significantly increase learner performance. The study involved Grade 9 learners who were struggling with mathematics and had been failing the subject for some years being given extended time in class, more than half (48 minutes) of which was for teachers to give extra help to the learners as they often experienced problems with understanding basic mathematical concepts, while the other 43 minutes were used for formal instruction. During formal instruction, teachers used a variety of ways, including games to appeal to learners with different learning styles. Nevertheless, the end of year examination results showed no improvement (Calhoun, 2011).

2.2.1.4 Appropriate level of instruction

To set the instruction at the appropriate level, characteristics of learners and their socio-economic background must be taken into account (see Filipatou & Kaldi, 2010; Graham & Provost, 2012)

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Characteristics of learners and mathematical achievement

Giving consideration to the characteristics of learners can also bring improvement in learner performance. In a study undertaken in Greece by Filipatou and Kaldi (2010), the performance of learners improved significantly after being given a project-based instruction in which they performed hands on activities and fieldwork. The study employed mixed methods (experimental and case study) with participants being fourth Grade learners of mixed abilities. However, the case study results indicated that there was no significant increase in memory-based learning activities (recalling of concept), since some of the learners (low achieving) experienced problems with their working memories (Filipatou & Kaldi, 2010).

An action research study in Chicago, USA by Fenner, Mansour and Sydor (2010) found that differentiation of learning tasks had resulted in an improvement in achievement of learners who often struggled in academic activities. The study involved Grade 6, 7 and 8 learners who were given a pre-test to determine their level of academic performance. The intervention consisted of differentiated tasks such as tests and projects for learners of different abilities. In addition, learners of low academic ability were given positive messages as a source of encouragement. The post-test results showed a substantial increase in achievement of all learners as the differentiated tasks allowed them to grow academically in accordance with their individual abilities. Additionally, it was found that differentiation improved their motivation to learn (Fenner, Mansour & Sydor, 2010).

Learners' socio-economic status and mathematical achievement

Social background of learners can have an impact on academic performance (Caro, McDonald & Willms, 2009), some of the factors being parental education and income (Sirin, 2005). This was shown by the results of a survey study conducted by Faroog, Chaundhry, Shafiq and Berhanu (2011) in Lahore Pakistan, the aim of which was to determine the effects of parental education and socio-economic status on performance in mathematics. The participants were 650 Grade 10 learners from 12 schools across Lahore, whose examination results were used as a measure of their mathematical achievement. Questionnaires were also used to obtain

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information on the level of education of parents and their occupations. The results of the study indicated that children of low socio-economic status (SES) performed less well than their counterparts with high SES. The study also indicated that learners with low SES often had parents with no or low level education as measured by qualification, such as primary school certificate, whereas those with high SES had highly educated parents (Faroog, Chaundhry, Shafiq & Berhanu, 2011).

Parents' level of education can affect involvement in their children' education, therefore, highly educated parents are able to give academic assistance and so motivate their children. The result can be high scores in subjects such as mathematics (Ademola & Olajumoke, 2009), but on the other hand, Caro, McDonald and Willms (2009) assert that while SES affects learner achievement the effect may vary with age. Younger learners (7-11 years) often are less affected than their older counterparts (11-15 year old). This conclusion was reached after conducting a longitudinal study in which 6,290 Canadian children were followed from Grades 2 to 8 to find if the achievement gap associated with SES widened with age. Questionnaires were used to gather data on SES while mathematics computation tests were used to measure ability to carry out basic mathematical operations such as additions, subtractions, decimals, fractions and percentages. The results indicated that the effects of SES on achievement were less severe in the lower grades (2–6) as compared to the higher ones (7-8) (Caro, McDonald & Willms, 2009).

Graham and Provost (2012) also found a gap between the level at which learners of various backgrounds achieve and that this gap increases with age. They reached this inference after studying learners' performance in mathematics from kindergarten to Grade 8 in New Hampshire, USA. The multi-year longitudinal study involved 15,260 kindergarten and 7,216 Grade 8 learners from rural, urban and suburban schools. The results showed that at kindergarten level rural learners often performed lower than their urban and suburban counterparts by one and two points respectively. On the other hand, the Grade 8 results indicated that the achievement gap between the rural, urban and suburban continued increasing. The rural learner achievement in mathematics was two points and six points lower than that of their urban and suburban learners correspondingly (Graham & Provost, 2012). Factors that contribute to the results of the rural learner were parents with lower educational qualification, especially in mathematics, a drawback as thy tended to have limited participation in their children' learning. To compound the situation, rural schools tended to have fewer resources and seldom attracted or retained highly qualified teachers (Graham & Provost, 2012). While Burney and Beilke (2008) agree that factors such as setting (rural or urban) and language can impact on learner performance, they regard the greatest influence as being poverty, because learners from poor families frequently have no access to programmes outside school that provide enrichment opportunities to enhance learner competence. Lacour and Tissington (2011) report that lack of resources such as financial, emotional, physical, role model and support system can lower learner performance, but correct choice of instructional strategy can improve that of learners from poor backgrounds.

The above indicates use of teaching strategies within which four core elements of instructional process are embedded, namely, quality of instruction (e.g., Kim, 2005), incentive to learn (e.g., Crow & Small, 2011), appropriate level of instruction (e.g., Fenner, Mansour & Sydor, 2010), and time on task (e.g., Rivera & Waxman, 2011).

2.2.2 Assessment strategies and mathematical achievement

Studies on assessment have mostly concentrated on *summative* and *formative* assessments (Doig, 2006), the former concerned with measuring what has been learned and taught, frequently results in granting of qualifications, while the latter involves determining what needs to be taught and learned. Thus, the results of formative assessment should be used to direct the instructional process (Cowan, 2009) and is regarded by McNamee and Chen (2005) as assessment *for* learning as opposed to summative assessment *of* learning. For Cowan (2009), through formative assessment learners tend to develop awareness of their own learning and are encouraged to apply their knowledge to various situations. Various assessment approaches addressing their relationships with learner achievement are examined in sections 2.2.2.1 to 2.2.2.3, taking into consideration the following.

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2.2.2.1 Quality of instruction

The following strategies can impact the quality of assessment and the achievement of learners in mathematics (see Watson, 2006; Manalo & Uesaka 2006).

Formative assessment strategy and mathematical achievement

Teachers often conduct assessment in different ways, but the purpose is often to monitor learner progress, diagnose learner needs in the subject and inform instructional strategies in the classroom (Craig, Butler, Cairo, Woods, Gilchrist, Holloway, Williams & Moats, 2005). Assessment strategies can have an impact on learner mathematical achievement, as illustrated by case studies on the assessment practices of two Grade 7 mathematics teachers in England (Watson, 2006). One teacher assessed in such a way that, during the lesson, learners were expected to use familiar mathematical procedures to identify complex and abstract mathematical properties then make general statements and justify them. The other teacher used pre- and post-lesson assessment which consisted of mathematical activities intended to develop the learners' mathematical thinking and understanding while still focusing on the content. The results of learners in both classes indicated an improvement in performance in comparison to previous achievement results (Watson, 2006).

Mathematical skills versus mathematical thinking skills strategy and learner achievement

The two cases discussed above (2.2.2.1) show assessment strategies that are in line with Lawson and Suurtamm's (2006) report that assessment should require learners to construct solutions, communicate their reasoning and demonstrate their understanding of mathematics. A study of six high performing schools (two primary, two junior secondary and two high) was conducted in Tennessee, USA, to highlight what assessment factors these schools had in common. The findings revealed that they all assessed in a way to equip their learners with mathematical skills (Craig et al., 2005). However it has been shown that mathematical skills do not prepare learners sufficiently for high performance in international achievement tests such as

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the TIMSS. An investigation into the Grade 8 learner performance results in TIMSS-R, 1999, indicated that assessment in Israel and USA focused on content and mathematical skills and the two countries' learners achieved far below Singapore, whose assessment strategies were found to concentrate more on mathematical thinking skills than just mathematical skills (Birenbaum, Tatsuoka & Xin, 2005).

Though good assessment is important for learner achievement, research shows that not all teachers know how to conduct assessment properly. Black, Harrison, Hodgen, Marshall and Serret (2010) discovered that many mathematics teachers tend to use more formal testing, which is summative assessment, and teach learners to pass the tests rather than to understand mathematics. Teachers often rely on questions from past external question papers without considering how appropriate they are in addressing a specific skill or conceptual understanding. Many seldom know what to look for or document during formative assessment, nor are they sure of how to use the information gathered from learner strengths and weaknesses to enhance their instructional process (McNamee & Chen, 2005). However, some use assessment not only to help learners acquire mathematical understanding and knowledge but also to develop their mathematical thinking skills such as logical, divergent, inductive and procedure management thinking skills. Learners such as the Singaporeans participating in TIMSS who possess these skills are often top achievers in mathematics (Birenbaum, Tatsuoka & Xin, 2005).

The results of a study in Canada (Nico, Kelleher & Saundry, 2004) established that mathematical thinking skills can develop in learners even at a younger age, if assessment tasks are designed to promote it. The study involved Grade 1 learners who were provided with blocks to answer questions related to estimating, counting and grouping of numbers, while explaining their every move of the blocks. Learners gave different, but relevant explanations to support their mathematical reasoning, however, not all were able to use counting as a way of making sense of the numbers, particularly those with strong visual spatial sense or poor auditory-verbal skills. They preferred to arrange the blocks into a collection and "appeared to use the rows and columns as scaffolds to thinking about grouping and part/whole relationship" (Nico, Kelleher & Saundry, 2004, p.150). This corresponds with the findings of a study by Francsali (2004) in the Bronx, USA, in which middle school learner mathematical attainment improved after being assessed in a way that emphasised explanation of reasons for solutions to mathematical problems.

Problem solving strategy and mathematical achievement

For assessments that are meant to find out what learners know in order to help them improve their skill, Smith and Macdonald (2009) point out that tasks that are related to real-life situations can give positive results, and suggest teachers should use more open-ended tasks to grant learners opportunities to learn more from the process of tackling the tasks, as in turn this will enlighten the teacher about their mathematical capabilities. This concurs with the results of the study conducted by the *What Works Clearinghouse* (2006) in which teaching and assessment tasks were focused on concepts and practice skills related to real-life situations, showing an increase in mathematical performance. This contrasts with Sparrow's (2008) opinion that students' understanding of mathematics can be enhanced by using assessment strategies that allow learners to practice their skills in real-life situations as opposed to tasks that are related to real-life situations. He states that instead of giving learners a task that is related to measuring room space, teachers should give a task that requires learners to make the actual measurement of the room space:

> *"Many textbooks attempt to use real mathematics by having children apply mathematical ideas to real world problems or setting tasks with a familiar context. This technique is useful as it allows children to see the connection of school mathematics to situations and contexts met by people outside the classroom. There are, however, two issues relating to the general use of applications and contexts. They both concerned with pseudo-relevance"*. (Sparrow, 2008, p.4).

Learners are often given assessment tasks that contain problems that need application of familiar procedures, thus the problems require them to use their memories rather than their understanding of mathematics. Since real life consists of various kinds of problems, they should be given assessment and learning tasks that need them to use various methods to discover the best solution to the mathematical problem (Cortic & Zuljan, 2009). In their study involving nine-year old mathematics students in Slovenia, Cortic and Zuljan (2009) instructed the experimental group in accordance with problem-based instruction, in which learners were assessed with tasks that contained problems such as those solvable in various ways, problems with no solution and problems with multiple solutions. The results of the post-test showed an improved performance of the learners in the experimental group in comparison with the control group which was instructed using the traditional approach.

Manalo and Uesaka (2006) also emphasise the importance of problem-solving strategy in the learning of mathematics and advocate for the use of diagrams in the solving mathematical word problems. They regard the strategy as efficient for reducing memory, computational and searching load in the learner. The findings of a study undertaken in New Zealand and Japan signified that use of diagrams in the teaching and assessment of learners can improve learner achievement. The 11- to 15-year old learners were given assessment tasks that involved use of diagrams to answer mathematical word problems. A considerable number of the Japanese learners, whose school curriculum emphasised the understanding of diagrams and concepts, could not use the diagrams to satisfactorily answer any mathematical word problem. On the other hand, the New Zealand learners were significantly equipped to solve simple mathematical problem using diagrams. However, as with their Japanese counterparts many of the New Zealand learners did not possess enough skill to solve complex problems, despite the curriculum in New Zealand putting emphasis on both the understanding of diagrams and their use as communication tool (Manalo & Uesaka, 2009).

2.2.2.2 Time on task

Learner engagement through assessment tasks outside school can be of importance to the instructional process and achievement of learners in mathematics (see Mikki, 2006).

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Types of assessment tasks and mathematical achievement

According to van Es and Conroy (2009), the type of assessment tasks that learners are often given shape their understanding of mathematics, for instance, when required to justify their thinking and explain how the approach was chosen, one learner's error can provide an opportunity for more enquiry. Learners may be asked to explain why they regard the answer and the approach as incorrect and to compare and contrast different approaches that may be followed to correct the error (Oaks & Star, 2008). Nevertheless, in their study of four middle school pre-service teachers' assessment strategies, van Es and Conroy (2009) found that the pre-service teachers' notion of engaging learners in reasoning about and explaining mathematical ideas was flawed. Their (pre-service teachers) mathematical questions were rarely of the kind to encourage deep thinking about the problem. Likewise, the findings indicated that the pre-service teachers seldom created situations in which learner talk was centred on reasoning, but rather the focus was regularly on application of mathematical procedures (van Es & Conroy, 2009). This was in contrast with Willms, Friesen and Milton's (2009) view that, since assessment for learning is meant to guide and improve the process of learning and teaching, tasks should be designed in a way that requires students to articulate their findings. Tasks should equip learners to be more self-directed in their learning process.

Homework can increase learners' engagement in academic activities and possibly the habit of academic self-discipline, motivation to learn and independent learning (Mikki, 2006). In his study of TIMSS 2003 mathematical achievements of learners in Latvia, Lithuania and Estonia, which were among the 12 best performing countries, Mikki (2006) discovered that there was no correlation between the amount of homework given to learners and mathematical outcomes. Teachers in the three countries put less emphasis on homework but their learners' achievements were high. Countries such as Japan and South Korea also performed well in the TIMSS 2003 and their teachers placed emphasis on homework (Mikki, 2006). On the contrary, the findings of a Pakistan national assessment in which middle school (Grade 8) mathematics learners were involved, indicated that there was correlation between frequency of homework and learner performance. Learners who received homework daily scored highly in the mathematics test when homework time was less than 30 minutes per day. Learners who seldom received homework and those whose homework lasted longer than 30 minutes per day often performed poorly (Tayyaba, 2010).

Warkenstein, Fenster, Hampden-Thompson and Walston's (2008) report indicate that grade level of the learner also contributes towards the success of homework in improving achievement in mathematics. They argue that the lower the grade (elementary phase) the less influence homework has on learner performance. Moreover, they view that in higher grades (middle and high school), teachers often use homework to reinforce learning by giving tasks that are based on the lesson presented in class. As such, this frequently has an impact on learner attainment. Another interpretation given to significant amount of time for homework and low achievement is that low achieveing children need a lot of homework for remedial purposes.

2.2.2.3 Incentive to learn

Motivation of learners can be influenced by the use of summative assessment strategies in mathematics (see Moss, 2012).

Summative assessment and mathematical achievement

In summative assessments such as examinations, learners often do not perform up to their full potential for reasons such as anxiety and lack of motivation (Harlen, 2005). Learner motivation can be boosted by using incentives and rewards; however, the increase in learner performance has been established to be variable in accordance with the academic ability (Hacker, Bol & Bahbahani, 2008). In their quasi-experimental study in Utah, USA, Hacker, Bol and Bahbahani (2008) informed students in the experimental group that they would receive extra points for greater accuracy in their examination while the comparison group received no offer of such an incentive. The results indicated that there was no significant difference in performance of the two groups. However, there were significant differences between high performing learners and low performing learners irrespective of the

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group they belonged to. The difference was considerably in favour of the high ability learners.

Findings of a study in Pennsylvania, USA, of the effects of high stakes national testing in middle school indicated that summative assessment had a negative influence on motivation of teachers, as it does with motivation of learners. Teachers were found to be frequently spending much time training learners for the tests rather than assessing in such a way that their developmental needs were taken into consideration (Caskey, Musoleno & White, 2010). This aligns with the findings of a study in Australia among middle school teachers which ascertained that they found it difficult to give quality instructional measures and comply with quality control measures of the national testing. Most teachers were reported as being concerned with accountability issues that were related to national testing rather than focusing on the quality of mathematical tasks in which they engaged their learners (Dimarco, 2009).

In Ohio, USA, some schools spent extra time and money trying to prepare learners for the state accountability tests. The case studies of four high achieving secondary schools revealed that teachers were paid to offer extra tuition to learners who needed help and if they passed the teachers were rewarded with a bonus. The instructional strategies employed were chiefly traditional with emphasis on drilling. The aim of the educational strategy was to teach to the accountability tests (Howley, Howley & Helm, 2007). In England, Buhagiar and Murphy (2008) found that many teachers' instructions tended to concentrate on learners with high academic ability as they thought they stood a chance of passing examinations. Nonetheless, these teachers indicated they often felt guilty for neglecting other learners and that concerned them. Teachers tended to use the results of assessment of learners for non-professional reasons, such as making prediction of examination results of their learners, instead of using them to prepare activities that could provide learners with support and guidance (Buhagiar & Murphy, 2008). This gives a signal of how important these summative assessments were being taken. The same emphasis is given to end-of-the-year results in South Africa, where in the Further Education and Training band (Grades 10-12), examination accounts for 75% of the learners' promotional mark (DBE, 2011).

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On the other hand, summative assessments can be of great benefit to learners, teachers and education authorities, with results used for external purposes such as certification, selection for employment and further education or in gauging the general performance of the school (Moss, 2012). This concurs with the research study undertaken in West Virginia State, USA, in which poor performing schools were identified using the results of the summative tests. The study involved Grades 4 and 8 learners who had achieved poorly in mathematics, mostly from economically disadvantaged background and/or with learning disabilities. The state assigned experienced educators to each school to provide school improvement coaching from 2004 to 2008. At the end of the programme, the summative assessment mean scores of the participating learners showed improvement (White, Hixson, Hammer, Smith, & D'Brot, 2010). Results of summative tests can also serve as sources of motivation to low achieving learners, on condition teachers can give non–judgemental feedback to learners. Feedback that is perceived as supportive rather than judgemental can encourage learners to put more effort into their studies. Additionally, Teachers can use the outcome of tests and examinations to decide on suitable instructional strategy for their learners (Moss, 2012) This concurs with Johnson and Jenkins's (2009) statement that summative assessment tasks can serve as guide to teaching methods and improving curricular to match the needs and interests of learners

2.3 NATIONAL STUDIES OF LEARNER ACHIEVEMENT

Whilst approaches to mathematics instruction have been widely researched internationally, in South Africa the studies have focused more on the issue of language (e.g., Howie, 2004; Bansilal & Wallace, 2008), problem-solving and mathematical skills (e.g., Barnes, 2005; van der Walt & Maree, 2007). This section contains a review of the following.

2.3.1 Teaching strategies and mathematical achievement

This sub-section contains studies in which the instructional process involved the usage of teaching approaches of problem-solving (e.g., van der Walt & Maree,

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2007) traditional (see Fleisch, Taylor, Herholdt & Sapire, 2011) and the use of language (e.g., Howie, 2004).

2.3.1.1 Quality of instruction

The problem-solving strategy and memorisation of so-called 'facts' on learner achievement are explained below. The way in which these strategies are used can impact on the quality of instruction received by learners (see van der Walt & Maree, 2007).

Problem-solving versus memorisation of facts and mathematical achievement

The intermediate phase (Grades 4 to 6) mathematics curriculum in South Africa emphasises the importance of developing problem solving, communication, critical thinking and reasoning in mathematics (DoE, 2002). This coincides with Barnes (2005) who reports that low achievers in Mathematics can be taught successfully when emphasis is placed on problem solving skills rather than on computation and arithmetic skills. However, research (van der Walt & Maree, 2007; Maree, Aldous, Hattingh, Swanepoel, van der Linde, 2006) conducted in South African schools indicates that often problem-solving strategy is either not being applied or applied incorrectly. Maree et al.'s (2006) study involving Grades 8 and 9 in Mpumalanga province found that the teaching of mathematics concentrated more on rote learning and memorisation of so-called 'facts', which are not in line with the curriculum guidelines. In a test given by the researchers, learners could not solve any non-routine mathematical problems (Maree, Aldous, Hattingh, Swanepoel, & van der Linde, 2006)

Additionally, a study conducted by van der Walt and Maree (2007) in Potchefstroom Ikageng area in the North West province discovered that teachers seldom implemented problem-solving strategies appropriately. While the teacher was found to have been posing questions that needed learners to think mathematically, the learners were not afforded opportunities to learn the strategy, which consisted of six steps of planning, execution, control, evaluation and reflection. Even when the teacher followed all the steps of problem-solving, which involved breaking the problem up into smaller parts, investigating the facts inherent to the problem and through thinking arriving at a solution, she often did not facilitate or mention these steps to the learners. This gave an indication that the teacher tended not to engage in the process of self-reflection in as far as her teaching strategies were concerned and her main focus was the coverage of the mathematical content (van der Walt & Maree, 2007).

When used correctly, problem-solving has been established as successful in improving learner achievement in mathematics. This is evidenced by the results of a quasi–experimental study conducted by Gaigher, Rogan and Braun (2006) in high schools in disadvantaged areas of South Africa, where the control group was instructed using non-problem solving strategies, and the treatment group was taught using the problem-solving approaches. A half-yearly examination which was written by all the learners in the two groups indicated an improved performance by the treatment group. This was in comparison to the results of the pre-intervention test which was administered and according to which the performances of the two groups were not significantly different (Gaigher, Rogan & Braun, 2006).

On the other hand, the findings of a study in Gauteng schools involving Grade 6 learners signified that there can be no difference in scores between learners instructed in a way that accentuates problem solving and those who were taught using drilling and memorisation of so-called 'facts'. The experimental group was instructed using a workbook with emphasis on mathematical operation in which learners were engaged in repetitive exercises with the aim of consolidating what has been learned. The control group was taught using the traditional textbook which promoted problem solving while also encouraging drilling of multiplication and subtraction table. The post-intervention test showed no significant difference in achievement between the two groups (Fleisch, Taylor, Herholdt & Sapire, 2011).

2.3.1.2 Appropriate level of instruction

Language and socio-economic status should be considered when teachers decide on appropriate level of instructing learners as they can influence the instructional process (see Howie, 2004; van der Berg, 2008).

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Impact of language on teaching and mathematical achievement

In studying the performance of South African learners in TIMSS 1999, writing a test in mathematics and science, Howie (2004) established that a correlation existed between performance in mathematics and English. The provinces which were more urbanised, such as Gauteng and Western Cape, performed better in both subjects than those that were predominantly rural, such as Limpopo, Eastern Cape and Mpumalanga. This concurs with a localised study by Maree and Erasmus (2007) undertaken in Mafikeng, North West province involving Grades 3 to 5 learners. The learners were given a mathematical test, part of which involved language. The performance of learners was very poor on the part which involved language and the learners indicated on a post-test questionnaire that they could perform better if they understood mathematical terms. Nonetheless, language seemingly does not affect the mathematical achievement of learners in countries in which they are second language speakers of English, as evidenced with Singaporean learners who were the top achievers in mathematics (TIMSS,1999), despite being the non-native speakers of English (Howie, 2004).

In South Africa, English language was often associated with elitism, power, access to higher education and employment, and the idea of learning mathematics in an African language was seldom preferred by both learners and educators who were African language speakers (Setati, 2008). This was discovered by Setati (2008) in her case study of Grades 4 to 6 teachers and Grade 11 learners of mathematics in Soweto Township, who preferred to teach and learn in English despite seldom having confidence in the language. Neither the teachers nor learners associated understanding of mathematics with fluency in a language of instruction, thus, they did not realise that language is a communication and thinking tool and mathematics involves both factors. In their delivery of the lessons teachers often switched between Zulu or Tswana and English, a strategy that resulted in conceptual discourse as they used African language and procedural discourse when English was used (Setati, 2008). Conceptual discourse is the discussion of why particular ways of solving a mathematical problem were used, whereas procedural discourse is a conversation in which the focal point is the steps followed in doing so (Setati, 2005). When practiced correctly, alternating the home language and the language

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of instruction can be advantageous to the learning process as learners can use the former to seek clarity about the instruction and to explain their points of view (Ferreira, 2011). On the other hand, alternating languages can be a challenge, when learners in one class speak more than one home language, as is often the case in South Africa (Ferreira, 2011). It is important for learners to learn the content and the language of instruction simultaneously in a multicultural class, which means use of the teaching strategy known as Content and Language Integrated Learning (CLIL), which involves teaching the subject through the language which is not the learner's first language, can be helpful. The main benefit of CLIL is that learners gain content knowledge while encountering the second language through which they will be assessed (Ferreira, 2011).

As a response to the effects of language, Barnes (2005) argues that language development strategies, such as discussion with and among learners as a way of acquainting learners with both the language of instruction and mathematical language, should be used frequently. Another strategy that yielded positive results in mathematics achievement among second language speakers of English in North West province was the use of a booklet which contained core mathematical terms in English and African languages. In a quasi-experiment, the performance of the treatment group signalled an improvement in performance after the use of a multilingual explanatory booklet of concepts in mathematics learning (Botes & Mji, 2010). Another issue that was discovered to be affecting the mathematics learning of Grade 12 learners in Soshanguve in Tshwane North, Gauteng was the lack of clear teaching strategy by teachers. Learners indicated that learning would be easier if their teachers were patient and clear in their explaining of the content (Makgatho & Mji, 2006).

Influence of socioeconomic status on mathematical achievement

The socio-economic background of learners can play a crucial role in the performance of learners in academic activities. This was evidenced by the results of a quasi-experimental study involving 79 learners of 12 to 15 years of age in the Western Cape province of South Africa. The learners were of different socio-economic backgrounds and attended either a private or public school. The SES was

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established by asking for the parents to fill out a biographical and demographical questionnaire (Maswikiti, 2008) and learners were asked to supply information on the type and size of their family dwellings, the neighbourhood they lived in and the provider of their household. The learners' school reports were used as measures of their mathematical achievement. The results of the study indicated that learners with low SES performed at lower level compared to their high SES counterparts irrespective of whether those learners were in low performing schools (Maswikiti, 2008). On the other hand, Taylor, van der Berg and Burger (2012) are of the opinion that while the SES of the learner plays a role, performance of the learner is often affected by that of the school. Schools with low SES are often characterised by low level of functionality which can impacts negatively on curriculum coverage and mathematical activities given to learners. This concurs with van der Berg's (2008) report that family SES had less impact on learner test scores. This was evidenced by low performance of children from middle class families when they were not in enrolled in schools with high SES. The setting of the school often contributes to learner performance. The Nelson Mandela Foundation (2005) argues that schools in rural settings are faced with serious resource challenges that impact on the general quality of their results. These communities often live in poverty, which is indicated by lack of basic services such as electricity, which play a major role in learning. This results in learners having to resort to the use of candles, which some learners can still not afford to buy. Schools in rural areas often lack teaching and learning resources and teachers are less qualified.

2.3.2 Assessment strategies and mathematical achievement

In this sub-section, studies focusing on assessment strategies and mathematical achievements are discussed, centring on quality of instruction and appropriate level of instruction as components of the process of instruction (see Vithal, 2004; Howie, 2003).

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2.3.2.1 Quality of instruction

The quality of instructing learners can be influenced by the use of a variety of assessment approaches (see Vandeyar & Killen 2003, 2007). These approaches can include those described below.

Variety of assessment approaches and mathematical achievement

Since South Africa followed an OBE policy at the time of data collection for SACMEQ II (replaced by Curriculum and Assessment Policy Statement in 2012) which placed the learner in the centre of instructional activities, the assessment of learners should have been made in a variety of ways, both formally and informally at school level, to indicate that teachers tended to conduct assessment in a more traditional way, often with the purpose of holding learners accountable rather than to find out what they knew. In a Grade 4 class in a South African school, a study indicated that the teacher assessed learners without assessment criteria and the questions on the paper were not of varying degrees of difficulty to accommodate learners of various mathematical abilities (Vandeyar & Killen, 2007).

Vandeyar and Killen (2003) argue that assessment tasks that are based on learners' real-life problems are often easy to understand as opposed to when the context is unfamiliar to them. In their case study of the assessment practices of a Grade 4 teacher in a South African multicultural classroom they established that the word problems that learners were given to solve were related to Afrikaans and English environments only, although the class was composed of White, African and Indian learners. This was in direct contradiction to the principle of Outcomes Based Assessment that states that tasks be meaningful to learners (Vandeyar & Killen, 2003). On the other hand, a study conducted by Vithal (2004) in Durban KwaZulu-Natal, found teachers who assessed learners in a way that related to their everyday life and still allowed them to apply mathematical skills, such as problem-solving and critical thinking. Grade 6 learners were given a project task which they were expected to carry out in groups. The results of the project were an improvement not only in mathematical skills, but also in the level of confidence shown by learners in doing their work. This corresponds with Stears and Gopal's (2010) idea that assessment strategies should assess more than knowledge as these strategies should incorporate social, emotional and physical skills. They therefore clarified that social skills are best assessed with discussion and group work.

2.3.2.2 Appropriate level of instruction

Language is an important factor for deciding upon appropriate level of assessing learners and can influence the learner achievement (e.g. Setati, 2005).

The impact of language on assessment and mathematical achievement

Language plays an important role in assessing learner progress and it is imperative to ensure that there are no barriers that may impact on learner achievement (Bansilal & Wallace, 2008). Nonetheless, researchers such as Setati, Chitera and Essien (2009) are of the opinion that the effects of language on assessment are major and identified various strategies that can be used to improve assessment and achievement, namely, code-switching and deliberate use of learners' home language. With code-switching, the teacher alternates the use of English and the learners' home language, while in the deliberate usage of learners' home language; the teacher can explain assessment tasks in the language of instruction as well as other languages present in the class. This is in unison with Howie's (2003) report that in South Africa the effects of language on achievement in mathematics are worse when the learners' proficiency in the language of instruction (English) is low. She pointed out that this was often the case with learners who spoke African languages at home.

Setati (2005) suggests that, since South Africa encourages the usage of all 11 languages in teaching, the language policy should be formulated to allow assessment to take place in multiple languages. Thus, assessment tasks should be set in more than one language and learners be allowed to answer in the language of their choice. This suggestion was made after Setati (2005) undertook a case study of a Grade 4 teacher whose teaching practices were better than her assessment practices since she could use an African language in addition to English when teaching, but could not use the same strategy when assessing

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learners. The result of the assessment task was learner mathematical performance which was far from being satisfactory. This was in contradiction to what the Revised National Curriculum Statement (RNCS) aimed to achieve. The process of instruction in 2007 when the SACMEQ III data was collected was directed by the RNCS. Some of the features of the RNCS were that a learner who has achieved mathematical knowledge, skills and values would be able to describe suitable situations using mathematical notations and language, display critical and insightful reasoning and interpretative and communicative skills when dealing with mathematical and contextualised problems, participate equitably and meaningfully (with awareness of rights) in political, social, environmental and economic activities by being mathematically literate, apply mathematics in a variety of contexts, transfer mathematical knowledge and skills between learning areas and within mathematics and display mental algorithmic and technological confidence and accuracy in working with numbers, data, space and shape, investigating patterns and relationships, problem-solving and constructing new insights and meanings (DoE, 2002). Despite the educational reforms which incorporate changes in ways of instruction, Jita and Vandeyar (2006) found that teachers still used the traditional instructional practices in mathematics.

The discussion on national studies highlights language, socio-economic status, problem-solving and memorisation of so-called ‘facts’ as strategies in the process of instruction. These address the issue of quality of instruction received by learners as well as the appropriate level at which the instruction should take place.

The above review of literature indicates some convergence and difference in approaches to instructional practices between those undertaken in South Africa and those reflected in international studies. While both place emphasis on constructivism as an approach to teaching and assessment, the local researchers address at length the issue of language in instruction as well as the deficits in the teaching strategies used and the international researchers seem to focus on the issue on self-efficacy, motivation, time on task and the use of technology in mathematical instruction.

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2.4 CONCEPTUAL FRAMEWORK

This study is based on a conceptual framework adapted from Slavin's 1995 model of effective instruction (also known as QAIT Model) (see Figure 2.1 below). Slavin's model consists of two sets of variables, which are student variables of *aptitude* and *motivation* as well as the alterable variables which are *Quality of instruction*, *Appropriate level of instruction*, *Incentive to learn* and *Time to learn* (QAIT). The student variables have both direct and indirect relationships with achievement. The motivation that learners bring into the classroom and their aptitude, which may be influenced by aspects such as prior learning in the subject, are determinants of how they will perform in learning activities. On the other hand, the two variables have an effect on the efficiency of instruction which in turn impacts on learner achievement. The student variables are elements that cannot be directly changed by the teacher (Slavin, 1995). Therefore, student inputs are not directly the responsibility of the teacher, nor part of this study.

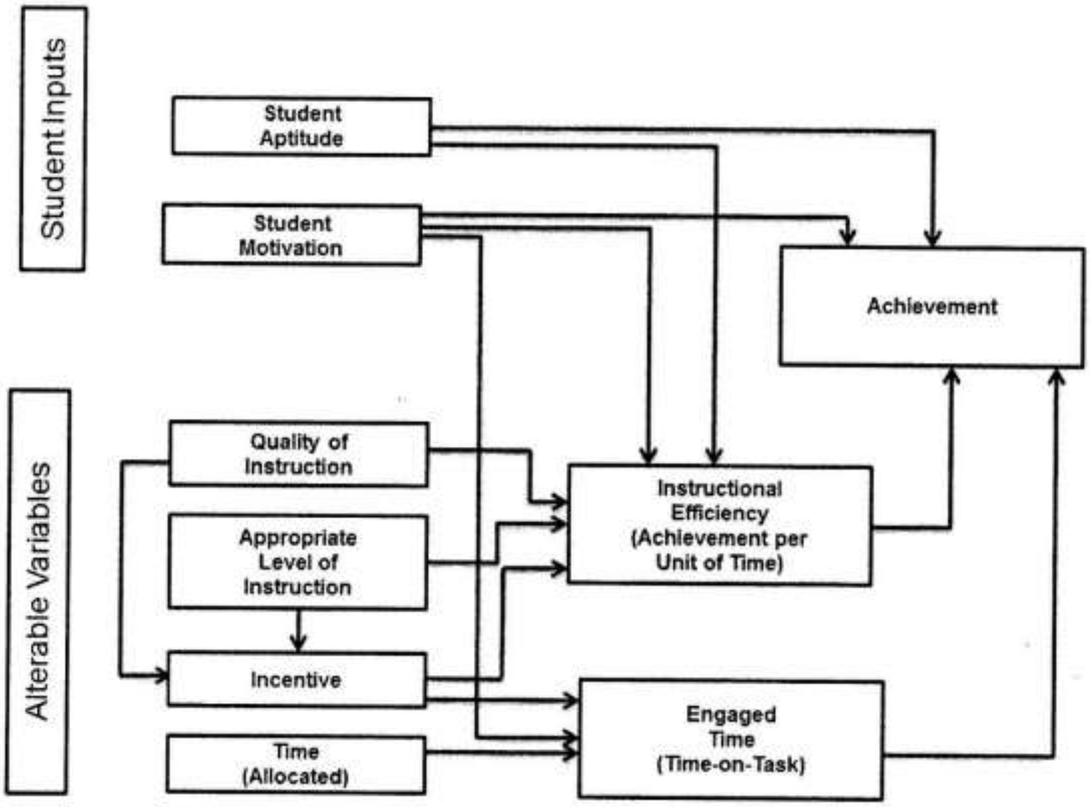

Figure 2.1: Slavin's effective instruction model (source: The Education Forum, 1995)

2.4.1 Alterable variables

Alterable variables are elements of instruction that are directly under the control of the teacher. They are variables that can be modified by the teacher. The alterable variables of quality of instruction, appropriate level of instruction and incentive to learn have a direct bearing on achievement via instructional efficiency while time (engaged time and allocated time) are directly related to learner achievement. The four elements of the QAIT model are described below.

2.4.1.1 Quality of instruction

Quality of instruction involves the degree to which learners can understand the information that is being presented to them. The teacher should present the lesson in an organised way using a variety of techniques, with the objectives of the lesson being clear. There should be clear relationship between the lesson and assessment of learners (Slavin, 1995).

2.4.1.2 Appropriate level of instruction

The pace of instruction and the instructional activities should be in line with the developmental stage of learners. This is important, especially if the class consists of a highly heterogeneous group of learners. Other methods such as ability grouping can be used to adapt lessons for learners of various abilities (Slavin, 1995).

2.4.1.3 Incentive to learn

Learning can be successful if learners are encouraged to learn and this should happen at classroom level. Teachers should stimulate the interest of learners on the subject through usage of extrinsic incentives such as praise and stars. Other methods such as cooperative learning, whereby learners are divided into small activity working groups, can also be used. Intrinsic motivation can be increased by giving activities that encourage curiosity from the learners (Slavin, 1995).

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2.4.1.4 Time

Time is imperative for learning and teaching and this refers to both allocated time and engaged time. Allocated time is time assigned for a specific learning and it is controllable by a teacher while engaged time is time learners spend doing activities and includes engagements outside the school. The amount of time learners spend engaged in learning activities is often related to how they make sense of the instruction (Slavin, 1995).

As this study sought to analyse data from SACMEQ III, it was limited to the variables available in SACMEQ. The four elements of Slavin's QAIT model are the responsibilities of the teacher and this study is based on the three of them, namely, quality of instruction, appropriate level of instruction and time. Incentive to learn was excluded because the SACMEQ III study did not have data that addressed it. The alterable variables are shown on the adapted model for this study (Figure 2.2 below) which also reflects the variables that are part of SACMEQ III data showing where the variables are conceptualised within the QAIT model for this particular study.

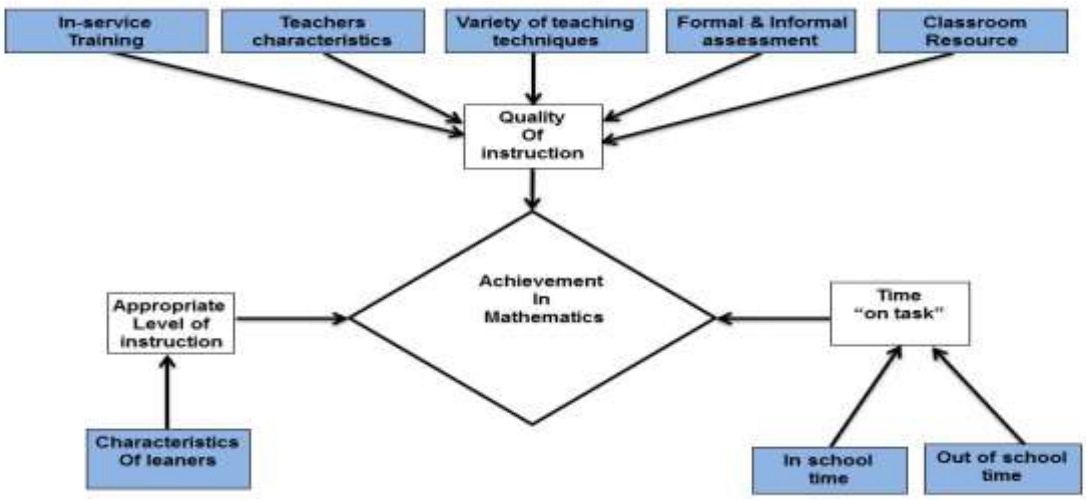

Figure 2.2: Instructional efficiency model adapted from Slavin's (1995) model of effective instruction

The three elements of the instructional efficiency model created for this study are described below.

2.4.1.5 Quality of instruction

Good quality of instruction involves systematic presentation of content in a variety of ways which will have different effects on learners (Astleitner, 2005). Good instruction supports learners in thinking and learning as well as motivating them to want to do well. Instruction produces desired results when the learning process is guided, learning progress is assessed using various methods and feedback on tasks is given to learners regularly. The instruction should be focused on objectives that are clear to both the teacher and learners (Astleitner, 2005). Furthermore, Samuelson (2010) explains that different teaching approaches have different impact on learner mathematical proficiencies. Approaches such as problem-solving, traditional and discussion are all important depending on the instructional goal to be achieved. Another factor that influences the quality of instruction is teacher qualifications. Learners with teachers who possess three years or more of training often perform highly especially if the schools have availability of resources that can enhance the process of instruction (Passos, 2009). The availability of teaching resources is of importance for achieving good results in mathematics. Yara and Otieno (2010) have found a positive relationship between learner scores in Mathematics and teaching and learning resources. This implies that schools with good quantity of resources tend to produce good learner mathematics results.

2.4.1.6 Appropriate level of instruction

Good teachers adapt their teaching taking into account the background and characteristics of their learners. In this study appropriate level of instruction is broadened to include background and personal developmental stage while in Slavin’s (1995) model it refers only to developmental stage. Learner characteristics such as socio-economic background, prior knowledge and language can influence learner achievement. Learners with high SES tend to perform better than those with low SES (Caro, McDonald, & Willms, 2009). Learners whose home language is different from the language of instruction often perform poorly compared to those whose home language is same as the language of teaching and learning (Hoyle, O' Dwyer & Chang, 2011).

2.4.1.7 Time

The RNCS which directed teaching and learning in 2007 when the SACMEQ III was conducted, stipulated the length of the period as 30 minutes in Grade 6 (DoE, 2002). A wise allocation and efficient use of instructional time increases the chance of having a successful learning. Additionally, a good use of out-of-school time can enhance learner academic achievement, whilst in-school engaged time consists of learner attending to learner materials and tasks, making appropriate motor responses, for example, writing and students asking for assistance from the teacher (Johns, Crowley & Guetzloe, 2008). On the other hand, out-of-school academic engagement can include after school learning activities, such as homework, weekend and school holiday learning (Beckett, Borman, Capizzano, Parsley, Ross, Schirm & Taylor (2009).

2.5 CONCLUSION

In this chapter, scholarly literature review was undertaken to identify previous research revealing relationships between instructional practices and learner mathematical attainment. This review provided guidance in the identification and selection of variabes from the SACMEQ database. The review incorporated research studies undertaken internationally and nationally. Factors that were addressed by the SACMEQ III data, which are: forms of assessment, and characteristics of learners, engaged and allocated time and characteristics of teachers formed the central part of the literature review. These variables were addressed in line with the four elements of the instructional efficiency model adapted from Slavin' QAIT model.

In the next chapter, research methodologies for the SACMEQ III project as well as the present study are described.

CHAPTER 3:
RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this chapter, the research design that was used in the SACMEQ III project is firstly presented in section 3.2, including the research design and methods such as sampling, the data collection process, data analysis, methodological norms and ethical considerations. Thereafter, design and methodology for this study are described in section 3.3.

3.2 THE SACMEQ III RESEARCH DESIGN AND METHODOLOGY

In this section, the research design (3.2.1) and research methods (3.2.2) followed in the SACMEQ III project are described.

3.2.1 Research Design

The SACMEQ III project, like the SACMEQ I and II, was a cross-sectional survey study (Gay,Mills & Airasian, 2009). Cross-sectional surveys involve the usage of data collected at one point in time to measure current practices and can be repeated periodically (Creswell, 2008). Together with 14 other countries, the study was conducted across South Africa (including Mpumalanga province) and data collected in September 2007 to gather information about conditions of schooling and the quality of education offered at primary school level. Questionnaires for learners, teachers and school heads were used to collect information on learners' socio-economic status (SES), Grade 6 Mathematics and Reading teacher instructional practices, and the school. Achievement tests were given to Grade 6 learners and teachers in Mathematics and Reading, as well as assessments of their knowledge of HIV/AIDS (Moloi & Chetty, 2010). The benefit of such a design is that enables researchers to generalise findings to the target population (Creswell, 2008). In the case of the SACMEQ III study in South Africa, the population comprised all Grade 6 learners nationally in 2007.

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3.2.2 Research methods

In this sub-section, the sampling process, data collection process, quality assurance measures as well as data analysis procedures followed in the SACMEQ III project are explained.

3.2.2.1 Sampling

The SACMEQ III study's desired population was all learners who were in Grade 6 in 2007 in the first week of the eighth month of the public school year. However, owing to certain factors, such as cost, learners in schools with fewer than 15 learners in Grade 6 were excluded. Moreover, learners with disabilities (special schools) were left out of the study as the assessment would not have been fair for them. South Africa's target population was 17 936 schools, of which 400 were originally sampled, but data was collected in 392 schools. A total of 9 071 learners were involved in the study (Moloi & Chetty, 2010), for Mpumalanga 775 learners from 38 schools, while Gauteng had 1 562 learner respondents in 78 participating schools

The sampling process followed a two-stage stratified approach in which schools were first divided according to provinces then size of the schools. Thus, a Probability Proportion to Size (PPS) method was employed, for which the likelihood of a sampling unit being selected is proportional to its size. With the provincial stratification, the sampling frame was divided into provincial lists, while with school stratification lists of all learners in Grade 6 in a school were used. A simple random sampling method, according to which a fixed number of 20 learners were selected for participation from across the grade, was used (Moloi & Chetty, 2010).

3.2.2.2 Instruments

The instruments used in the collection of data for SACMEQ III and administered to learners, teachers and school heads in each of the sampled schools are outlined below.

Learner achievement tests and questionnaire

Learners were given achievement tests in Reading and Mathematics as well as a questionnaire to collect data on demographic and home background. The Reading test covered three performance areas, namely: narrative prose, expository prose and documents. A total of 55 multiple choice items were administered to test various skills classified under eight levels of competency, namely: pre-reading; emergent reading; basic reading; interpretive reading; inferential reading; analytical reading; and critical reading (Moloi & Chetty, 2010).

The Mathematics test consisted of 49 multiple choice questions which covered three domains: *numbers,* which included operations and number line, square roots, rounding and place value, significant figures, fractions, percentages and ratios; *measurements item*, which covered measurement related to distance, length, area, capacity, money and time; and *space data*, which included geometric shape, charts (pie, bar, line) and tables of data. The items covered skills that ranged from pre-numeracy to abstract problem solving. The hierarchy of the skills tested as defined by SACMEQ is presented in Table 3.1.

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Table 3.1 Competency levels for Mathematics for the SACMEQ III study

LEVELS	SKILLS
Pre-numeracy	Application of single step addition or subtraction operations, recognition of simple shapes. Matching of pictures and numbers, counting in whole numbers
Emergent numeracy	Application of two step addition or subtraction. Operational checking or conversion of pictures to numbers; Estimation of length of familiar objects. Recognition of common two dimensional objects.
Basic Numeracy	Translation of verbal information represented in a sentence, simple graph or table using one arithmetic operation in several expected steps. Interpretation of place value of whole numbers up to one thousand. Interpretation of simple, common, everyday units of measurements.
Beginning numeracy	Translation of verbal or graphic information into simple arithmetical problems. Use of multiple different arithmetical operations in the correct order, on whole numbers, fractions and /or decimals.
Competent numeracy	Translation of verbal, tabular or graphic information into arithmetic form in order to solve a particular problem. Solving multiple operation problems using the correct order of arithmetical operations involving everyday units from one level to another e.g. metres to centimetres.
Mathematically skilled	Solving multiple operations (using the correct order of the arithmetical operations) involving fractions, ratios, and decimals. Translation of verbal and graphic representation information into symbolic, algebraic and equation form in order to solve a given mathematical problems. Checking and estimation of answers using external knowledge.
Concrete problem - solving	Extraction and conversion of information from tables, charts, visual and symbolic representation in order to identify then solve multi step problems.
Abstract problem - solving	Identification of the nature of unstated problem embedded within verbal or graphic information, then translation of this into symbolic, algebraic or equation form in order to solve the problem.

Source: SACMEQ (2010)

The learner questionnaire collected data on learners' socio-economic status (SES), background factors such as home possessions, parental education levels, quality of materials used to build homes, the regularity at which they received meals, and the frequency of English spoken at their home (Moloi & Chetty, 2010).

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The HIV/AIDS knowledge test was based on the curriculum framework for HIV/AIDS from the participating countries. A total of 86 dichotomous items addressing basic knowledge relating to protection against the disease were used. The items covered 43 curriculum topics and five main elements, which were definitions and terminology, transmission mechanisms, avoidance behaviours, diagnosis and treatment and myths and misconceptions (Moloi & Chetty, 2010).

Teacher achievement tests and questionnaire

Teachers were asked to complete a questionnaire on personal characteristics, professional characteristics, instructional practices and school activities. In addition, the Mathematics, Reading and Life Orientation teachers participated in subject-specific tests, similar in composition to those completed by learners with a few challenging items included, namely grade-specific questions that were pitched at a slightly higher level to test the efficiencies of teachers in handling the content (Moloi & Chetty, 2010).

School head questionnaire

The school principals were asked to complete questionnaires on information relating to the school. The questionnaire included items on teachers' level of training and their teaching experiences, learner-related problems, the resources available at the school and the level of community participation in school matters (Moloi & Chetty, 2010).

3.2.2.3 Data collection

The process of data collection occurred in September 2007 in all 392 sampled schools in South Africa, including 38 and 78 schools in Mpumalanga and Gauteng provinces respectively. The process was undertaken over two days. On the first day questionnaires on learner SES, teacher information and school information were completed. In addition, the English reading and HIV/AIDS tests were written. The data collected on the first day was checked over night to see if there was any missing or incomplete information and if necessary more be collected on the second day. On the second day, the Mathematics, English and HIV/AIDS tests were administered. The teacher tests were taken by those teachers who taught the largest number of the sampled learners (Moloi & Chetty, 2010).

3.2.2.4 Quality Assurance Measures

The SACMEQ III project used the same Reading and Mathematics tests as those used in project I and II, given that SACMEQ is a trend study. There were a few improvements made on certain items in the questionnaire, such as inclusion of Internet, computers, and digital cameras as possessions in the learners' homes. All of the instrumental items were reviewed to ensure relevance to the school curriculum of the time. A pilot study was undertaken to test them for the language being within the understanding of the Grade 6 learners and clear of cultural biases. The South African tests were made available in Afrikaans, in addition to English, by the language and assessment specialists at the University of Pretoria, ensuring that both English and Afrikaans versions were of the same standard. The statistical, content and reliability checks were carried out by specialists at the SACMEQ Coordinating Centre in Paris (Moloi & Chetty, 2010).

3.2.2.5 Data Analysis

To analyse the data, the Statistical Package for the Social Sciences (SPSS) software was utilised to construct new variables or to recode existing variables. For example, an index of SES was created by bringing together recoded variables that described possessions at home, materials used for building learners' homes and the frequency in which they received meals. For the next stage, specialised data analysis software from the International Institute for Educational Planning (IIEP), called IIEPJACK, was employed to fill the appropriate estimates and corresponding sampling errors into 'dummy tables', that is, "blank (or empty) data tabulation templates that employed the variables and information layouts that would be used in the final SACMEQ national policy reports" (Moloi & Strauss 2005, p.18).

3.3 RESEARCH DESIGN AND METHODOLOGY FOR THE PRESENT STUDY

In this sub-section, the research design and methodology employed in the present study are described. These consist of research design (3.3.1), research questions overview (3.3.2), SACMEQ III Items utilised for secondary analysis (3.3.3), data analysis (3.2.4) methodological norms (3.2.5) and research ethics (3.3.6).

3.3.1 Research design

This study is a secondary analysis of selected SACMEQ III cross-sectional survey data collected in 2007. A secondary data analysis is any further analysis of an existing dataset which presents interpretations, conclusions or knowledge additional to, or different from, those produced in the first report (Hakim, 1982). The SACMEQ III data has been further analysed to see if it could provide any understanding of the effect of instructional efficiency on Grade 6 learner performance in Mathematics in Mpumalanga. This secondary analysis is of a quantitative nature, which means the results can be generalisable to the entire population provided it was based on large sample which was randomly collected (Creswell, 2008). The population of this study were all Grade 6 learners in Mpumalanga, with a sample of 775 learners from 38 schools.

In this study regression analysis is used in the secondary analysis. The dependent variable is Grade 6 Mpumalanga learners' mathematical achievement and the independent variable involved their teachers' instructional strategies as reported for the SACMEQ III project and aligned to the conceptual framework (see Table 3.2, below).

3.3.2 Research questions overview

The study is underpinned by a post-positivist philosophy which asserts that truth depends on how people interpret evidence or how they give meaning to the world around them (Fisher, 1998). The post-positivist stance in research is that of critical realism, since it agrees that whilst reality exists it is not absolute. Therefore, the belief is that truth is based on probability rather than certainty, and in social reality knowing this reality will always be inhibited by human imperfections (Dimitra, 2010). The paradigm is against the belief that observation is the basis of all knowledge since it depends on theory, and this is always revisable. Post-positivism thus views knowledge as conjectural (Phillips & Burbules, 2000).

This secondary data analysis addresses the following research questions posed in Chapter 1: To recap, the main question is: What is the effect of instructional efficiency on Grade 6 Mathematics achievement in Mpumalanga in SACMEQ III?

The sub questions that were investigated were:

Sub question 1

How did Mpumalanga learners perform in Mathematics in SACMEQ III and how did it compare to Gauteng and South Africa? This is addressed by using the results of descriptive analysis of the learner achievement data.

Sub question 2

What is the relationship between characteristics of learners and their achievements in Mathematics? This question is answered using the results of correlation analysis of learner mathematical achievement data and learner and teacher questionnaire data.

Sub question 3

What is the relationship between Time on task and learner achievement? The results of the correlational analysis between learner mathematical achievement data and teacher questionnaire data are used in addressing this question

Sub question 4

What is the relationship between quality of instruction and learner achievement? The question is answered by using the results of correlational analysis between teacher questionnaire data and learner mathematical achievement data.

Sub question 5

What is the quality of instruction in Mpumalanga in relation to Gauteng and the overall South Africa and how does it influence Mathematics achievement? This question is addressed using the results of regression analysis of learner mathematical achievement and teacher and learner questionnaire data.

As indicated above, in answering the research questions the following was done: Based upon the conceptual framework, items from the SACMEQ III data were selected from the teacher questionnaire and learner questionnaire, the latter because learner background factors such as level of parent education and the frequency at which a learner receives meals can affect the success of teaching and learning. The learners' socioeconomic factors address the conceptual framework factor of *appropriate level of instruction*, which in the SACMEQ studies is concerned with characteristics of learners. The SACMEQ variables were analysed descriptively for missing data and to see which were often used by teachers in their teaching and assessment of learners in Mpumalanga, Gauteng and South Africa. Thereafter, the Pearson correlation analysis was undertaken for all the three groups to establish the type of relationships that existed between the instructional factors and mathematical achievement as described by the learner mean performance in SACMEQ III. Based upon the correlational analysis results of Mpumalanga, variables that fulfilled the criteria of r = 0.20 were selected for Principal Component Analysis (PCA) and Hierachical Multiple Regression analysis. PCA was used to reduce the quantity of data (Tabachnick & Fidel, 2007) so that it could be utilised in regression analyses. Mpumalanga data was used to select variables for PCA because it is the primary focus of the study. Hierarchical Multiple Regression analyses were then conducted on the reduced data to establish the extent to which the independent variables, which are characteristics of learners, teachers and instructional strategies in this case, can accurately predict mathematical achievement. The same variables were entered for the regression analysis for all the groups. This was to see how factors affecting Mpumalanga affect other two groups. Mpumalanga data was analysed in comparison with that of Gauteng and the overall South African sample. The reasons for the comparisons with are that Gauteng is Mpumalanga's neighbouring province which is recognised in various assessment standards as high performing. The comparison with the nation is to find out where Mpumalanga fits in the bigger

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picture. Furthermore, Mpumalanga shares some features but differs in others with Gauteng. Residents of both Mpumalanga and Gauteng speak many languages and differ in other aspects, for example, Mpumalanga is mainly rural while Gauteng is mainly urban. Mpumalanga is predominantly rural and South Africa has a large number of rural areas (though over 60% of its population live in urban areas).

3.3.3 SACMEQ III Items utilised for secondary analysis

This study used the SACMEQ III items reporting on instructional practices and teacher biographical data from the teacher and learner questionnaires. The items were chosen based on their alignment with the research questions and the conceptual framework (see 3.2.2). Table 3.2 (below) outlines the links between the items that were selected, the conceptual framework and research questions.

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Table 3.2: Items utilised for secondary analysis

SACMEQ original variables	**Conceptual framework**	**Adapted Conceptual framework**	**Factors**	**SACMEQ Scoring**
	QAIT variables	**Adapted variables**		
Possession at learner home	Appropriate level of instruction	Characteristics of learners	Basic electronics possessions Convenience possessions Basic household possessions Audio and communication possessions Transportation possessions Media possessions and table, Borehole and bicycle	1 = No 2 = Yes
Morning meal Lunch meal Evening meal	Appropriate level of instruction	Characteristics of learners	Breakfast Lunch Dinner/supper	1 = Not at all 2 = 1 to 2 times per week 3 = 3 to 4 days per week 4 = Everyday

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SACMEQ original variables	Conceptual framework	Adapted Conceptual framework	Factors	SACMEQ Scoring
Learner mother education Learner father education	Appropriate level of instruction	Characteristics of learners	Learner mother education Learner father education	1 = No school, no adult education 2 = No school, some adult education 3 = Some primary 4 = All primary 5 = Some training after primary 6 = Some secondary 7 = All secondary 8 = Some training after secondary 9 = Some university 10 = University 11 = Do not have 12 = Do not know
Floor material Wall material Roof materials	Appropriate level of instruction	Characteristics of learners	Type of dwelling	1 = Earth/clay 2 = Canvas 3 = Wooden planks 4 = Cement 5 = Carpet/ tiles
Pupil speak English at home	Appropriate level of instruction	Characteristics of learners	English spoken at learner home	1 = Never 2 = Sometimes 3 = Most of the time 4 = All of the time
Teacher Sex	Quality of instruction	Teacher characteristics	Teacher sex	1 = Male 2 = Female

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SACMEQ original variables	Conceptual framework	Adapted Conceptual framework	Factors	SACMEQ Scoring
Teacher years of teaching	Quality of instruction	Teacher characteristics	Teacher years of teaching/experience	None
Teacher age	Quality of instruction	Teacher characteristics	Teacher experience	None
Teacher academic Qualification	Quality of instruction	Teacher characteristics	Teacher academic qualification	1 = Primary 2 = Junior secondary 3 = Senior secondary 4 = A level 5 = First degree
Teacher professional qualification	Quality of instruction	Teacher characteristics	Teacher professional qualification	1 = No training 2 = One year 3 = Two years 4 = Three years 5 = >Three years
Effectiveness of teacher in-service training	Quality of instruction	In-service training	Effectiveness of in-service training	1 = No in-service training 2 = Not effective 3 = Reasonably effective 4 = Effective 5 = Very effective
Days in in-service training	Quality of instruction	In- service training	Number of days in in-service training	None

SACMEQ original variables	Conceptual framework	Adapted Conceptual framework	Factors	SACMEQ Scoring
In-service training courses	Quality of instruction	In-service training	Number of in-service training courses	None
Teacher classroom resources	Quality of instruction	Classroom resources	Chalk Writing board Wall chart Duster Cupboard Bookshelves Class- library Teacher table Teacher chair	1 = No 2 = Yes
Minutes per period	Time on task	Teacher allocated	Minutes per period	None
Teacher Number of periods per week		Time	Periods per week	None
Homework given	Time on task	Engaged time	Learner homework	1 = No homework 2 = Once or twice each month 3 = Once or twice each week 4 = Most days

3.3.4 Data analysis

To address the research questions, data was examined and transformed using descriptive analysis, correlational analysis, Principal Component Analysis, reliability analysis and Hierarchical Multiple Regression analysis (Creswell, 2008). As described below, the analysis took place in two stages, the first of which comprised descriptive analysis and correlational analysis. The second part consists of inferential analysis (Principal Component Analysis (PCA) and Hierarchical Multiple Regressions). The process of data analysis was undertaken using Statistical Package for Social Science (SPSS).

3.3.4.1 Descriptive and correlation analysis

Descriptive statistics were used to describe and present the data including frequencies, mean, median, mode, percentages and standard deviations. Moreover, the descriptive analysis helped to gain an overview of thoughts, feelings and behaviour of the participating learners and teachers (Field, 2009). In the second part, correlational analysis of the data was undertaken, whereby the Pearson correlation co-efficient was used to determine any relationship between instructional strategies and mathematical achievement. Correlation coefficient indicates the degree of association between variables, therefore the higher the co-efficient the stronger the association between the variables concerned (Gay, Mills & Airasian, 2009; Field, 2009). The purpose of using correlational analysis in this study was to identify relationships between potential instructional factors derived from the conceptual framework (see Chapter 2) and learner achievement, thus helping in identifying variables for regression. The results were used in the process of Hierarchical Multiple Regressions, described below.

The following criteria were used for accepting the results of correlation analysis. A correlation coefficient of 0.20 - 0.35 is considered weak and shows only a slight relationship between learner scores and the instructional practices. However, the coefficient is considered statistically significant for small samples of a few hundred. On the other hand, such a coefficient can only be usable for exploring the association between the variables not for prediction. Secondly, a correlation of 0.35

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- 0.65 is regarded as moderate and useful for limited prediction. Thirdly, a coefficient of 0.66 - 0.85 is regarded as strong and it can be used to give good prediction about the variables. Fourthly, a correlation of above 0.85 is regarded as very strong and indicates that the two variables measure the same underlying characteristic (Creswell, 2002). Mpumalanga correlational analysis results were used as a basis for selecting variables for the regression analyses. This means variables were entered in to the Hierarchical Multiple Regression models only if they fulfilled the minimum requirement of $r \geq 20$ based upon Mpumalanga results. This is because Mpumalanga is the primary focus of this study, whereas Gauteng and South Africa overall, are used for comparative measures as described earlier. Gauteng is Mpumalanga's neighbouring province that is recognised across different assessment standards as high performing. Comparison with South Africa is to obtain the bigger picture for where Mpumalanga fits in. A full description of the result from the descriptive and correlational analyses is undertaken in chapter 4

3.3.4.2 Inferential analysis

The second part of the secondary analysis consisted of inferential statistics applying Principal Components Analysis (PCA) and Hierarchical Multiple Regression analysis, the former being a statistical technique in which a large set of variables is grouped into fewer sets of closely related variables. Some of the SACMEQ III variables had large number of items which needed to be reduced (for example *learner home possessions*), and the Mpumalanga data was used for the conduct of PCA. PCA helped in reducing this number of variables into fewer components while retaining as much of the original information as possible (Tabachnick & Fidel, 2007). The main objective of Principal Component Analysis is to establish from a group of variables a component that accounts for as much of the total variance as possible (Field, 2009). Therefore, in this study several items related to a particular variable, for example, nine items related to mathematics teaching resources were analysed with the aim of reducing them to one or a few components which give a strong explanation of the construct. The Principal Component Analysis was conducted with orthogonal Varimax rotation, which improves the interpretability of each variable by maximising its loading on one of extracted factors while decreasing its loading on all other factors (Field, 2009).

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The minimum criterion for accepting the result of the factor analysis is that the new components must have an Eigenvalue of greater than 1. The higher the Eigenvalue the better the components explain the particular construct. Secondly, the Kaiser - Meyer–Olkin (KMO) measure of adequacy must be at least 0.50. The KMO indicates whether the variables entered for the PCA are sufficiently related to give meaningful result from the PCA. Thirdly, Bartlett's Test of Sphericity should be significant. Fourthly, the variable should have a minimum communality of 0.4, which means the variable must share a minimum of 40% of its variance with other variable. The higher the communality value the higher the relationship the variable has with others and the better suited it is for PCA (Field, 2009).

The new factors formed as a result of PCA were further analysed for internal consistency (reliability analysis) using Cronbach's alpha coefficient. The following criteria were used in dealing with reliability results. A coefficient of 0.50 - 0.60 was considered weak, 0.6 - 0.70 was regarded as moderate, and 0.70 – 0.90 was taken as good. Moreover, a coefficient of above 0.90 was regarded as great. While a criterion of 0.5 was considered the lower coefficient usable, in some instances, even lower coefficients of 0.4 were accepted due to their conceptual importance to the study. Another reason for accepting reliability coefficients of less than 0.50 was that the results are used only for research purpose. In other cases, some items were deleted with the aim of improving the degree of internal consistency of items. This was done after the item-deletion statistics indicated that the internal reliability could be improved by deleting such items (Field, 2009).

The next step involved conducting a Hierarchical Multiple Regression analysis. Factors that met the PCA acceptance criteria as explained above were entered for the regression analyses in all the three groups. Variables that were not entered for PCA, were entered in to the Hierarchical Multiple Regression models only if they fulfilled the minimum requirement of $r \geq 20$ based upon Mpumalanga results. According to Tabachnick and Fidel (2007), multiple regression analysis is a statistical procedure that permits the researcher to assess the relationship between one independent variable and several independent variables, as "… a powerful technique for untangling the complex and interrelated relationships between variables" (Dimitra, 2010, p.391). Hierarchical Multiple Regression is concerned with

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selecting predictor variable based on past research (Field, 2009). Petrocelli (2003) explains that Hierarchical Multiple Regression analysis is suitable where there are theoretical assumptions as well as examining the effect of a number of variables in a sequential way. The learner questionnaire included amongst others, items regarding socio-economic status (SES) whilst the teacher questionnaire provided items related to the process of instruction. Researchers such as Graham and Provost (2012 and Maswikiti (2008) found out that socioeconomic factors have more impact on learner achievement than school factors. Therefore, learner background factors such as possessions at learner home and parents' level of education were entered first and instructional factors were second. The aim of conducting multiple regressions was to develop a subset of predictor variables that could be utilised in predicting of learner achievement from variables related to instructional factors. Therefore, those variables that did not offer any additional prediction value to the dependent (criterion) variable were eliminated from the process. These are all variables which their contributions were statistically non-significant (Tabachnick & Fidel, 2007). This means, the Hierarchical Multiple Regression models for Mpumalanga, Gauteng and South Africa were refined depending on the result of first level analyses.

A model and summaries were created to provide an understanding of the extent to which the instructional factors were successful in predicting learner achievement. From the models, the R value was used to indicate the degree of associations between instructional factors and mathematics achievement. R value "is a measure of multiple correlations between the predictor and the outcome" (Field, 2009, p.224). Moreover, R squared values were also employed to describe the amount of variability in mathematical achievement resulting from instructional factors (Tabachnick & Fidel, 2007). For making sure that the success of the models in making prediction was not in doubt, only F-ratios with a value of <.001 was regarded as adequate. Concerning coefficients of the models the first to be used was the Beta values, which helped in explaining the association between the instructional factors in the models and learner achievements. Therefore, negative B value indicated a higher probability of low learner scores where such instructional factors were involved. Furthermore, to ascertain whether a particular instructional

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factor made a considerable contribution to the model a t-test (sig. level .05) was used (Field, 2009).

3.3.5 Methodological Norms

The methodological norms that the study observed are explained below. They are: validity and reliability.

3.3.5.1 Validity

This study focused on matters relating to content validity and construct validity. Content validity is concerned with measuring whether the items accurately represent the content being measured and it is a matter of expert judgement (Vogt, 1999), In order to measure whether the items correctly represent the content being measured, an expert knowledge of a curriculum specialist at the University of Pretoria was employed. The items on the teacher and learner questionnaire were confirmed to be relevant for measuring learner characteristics, teacher characteristics and instructional strategies. Construct validity was established concerning a particular concept, referring to how accurately variables measure the construct of interest. This helps to explain how well generalisations can be made from operations to construct (Vogt, 1999), To ensure the accuracy at which particular variables measure a particular construct, the number of items included in measuring that particular construct were looked into for example, for the construct of learner characteristics the questionnaire covered, possessions at learner home, meals received by learners, type of dwelling for learner home, the frequency at which learners speak English at home, learner parents' education. These items give a good indication that learner characteristics have been measured extensively.

3.3.5.2 Reliability

Reliability refers to the degree to which a research instrument can give consistent results across all situations (Field, 2009). A reliable instrument gives more or less the same data from similar respondents (Cohen, Manion & Morrison, 2007). Cronbach's alpha co-efficient was used to test internal reliability of the SACMEQ III data instrument, and gauge the extent to which the items measured one construct. An inter-item correlation coefficient was calculated to indicate how items are related to one another. Any items with an inter-item correlation value of 0.3 were deleted from the scale to improve its overall reliability. A Cronbach's alpha value of 0.7 and above is considered as high, thereby a measure of good reliability (Field, 2009). On the other hand, a Cronbach's alpha value of below 0.6 is regarded as an indication of weak internal consistency among items. However, since the value is used in social science research it has been accepted and used in this study (Field, 2009).

3.3.6 Research Ethics

Research ethics are principles and codes of conduct by which a researcher conducts his/her study (Basit, 2010). When a primary study such as the SACMEQ III project is undertaken the informed consent and voluntary participation of respondents is sought. Letters were written to the teacher and learner participants informing them of freedom of participation. Since the Grade 6 learners were minors, permission was sought from the parents and the SACMEQ ensured that there was protection of participants from harm. The details of the research were and shall be kept confidential and the participants' anonymity preserved (Basit, 2010)

For the present study, permission was sought from the SACMEQ South Africa and the Ethics Committee of the University of Pretoria to undertake the secondary analysis of the data collected in 2007 for the SACMEQ III project. During secondary analysis all the details of the participants are kept confidential, with only the researcher and the supervisors having access to them. The data will be stored for 15 years then destroyed as per University of Pretoria policy.

3.4 CONCLUSION

The chapter has described the research methodologies followed in the SACMEQ III project as well as in the present study. These included research designs and research methods. In the next chapter, the results of descriptive analysis and correlational analysis are presented.

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CHAPTER 4

THE RELATIONSHIP BETWEEN INSTRUCTIONAL EFFICIENCY AND GRADE 6 MATHEMATICS ACHIEVEMENTS IN MPUMALANGA, GAUTENG AND SOUTH AFRICA OVERALL

4.1 INTRODUCTION

In Chapter 3, a description of the design and methods used during the secondary analysis of the SACMEQ III data was given. The study seeks to find out the effect of instructional efficiency on Grade 6 learner Mathematics performance in Mpumalanga. Therefore, this chapter presents the results of statistical data analysis of the *characteristics of learners and teachers, teacher instructional strategies, and* factors related to *time on task* as contributors to learner mathematical accomplishment. These factors can have an impact on teacher instructional efficiency which is the independent variable for this study. The chapter is divided into six sections: mathematics achievement (4.2); characteristics of learners, teachers and instructional strategies used in mathematics classroom (4.3); the relationship between mathematics achievement and characteristics of learners, teachers and instructional strategies (4.4) and conclusion (4.5).

4.2 MATHEMATICS ACHIEVEMENT

Mathematics achievement, for the SACMEQ, is determined when a learner has attained one of the competence levels tested in Mathematics. Those levels are pre–numeracy, emergent numeracy, basic numeracy, beginning numeracy, competency numeracy, mathematically skilled, concrete problem solving and abstract problem solving (see Table 3.1 for more details). SACMEQ used a mean score of 500 with standard deviation of 100 for the measurement of learners' achievement. The results of Mpumalanga, Gauteng and South Africa are presented in Table 4.1.

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Table 4.1: SACMEQ III learner Mathematics scores

	Mpumalanga		Gauteng		South Africa	
	Mean	SE	Mean	SE	Mean	SE
	476.10	8.19	545.00	11.99	498.80	3.81

The mean score of Mpumalanga learners was lower than those from both Gauteng and South Africa. Furthermore, the mean score showed no improvement compared to its SACMEQ II project score of 486.10. Mpumalanga performance remained lower than the predetermined score of 500 set by the SACMEQ (see Chapter 3). The learner performances per competence level were also lower, as presented in Table 4.2 below.

Table 4.2: Percentage of learners reaching the mathematics competence levels

Competence level	Mpumalanga	SE	Gauteng	SE	South Africa	SE
Pre numeracy	5.4	0.86	3.1	1.10	5.5	0.46
Emergent numeracy	38.4	3.06	17.4	2.50	34.7	1.13
Basic numeracy	34.9	2.11	24.6	3.09	29.0	0.87
Beginning numeracy	13.9	1.75	21.4	1.53	15.4	0.67
Competent numeracy	4.2	1.21	16.1	2.56	7.1	0.61
Mathematically skilled	2.3	1.23	13.5	2.29	5.9	0.60
Concrete problem solving	0.5	0.43	3.1	0.87	1.9	0.42
Abstract problem solving	0.3	0.23	0.7	0.32	0.6	0.14

Source: Moloi and Chetty, 2010

Mpumalanga learners, like their South African counterparts, performed similarly at the first level of prenumeracy where about 79% and 69% respectively performed at basic numeracy level or lower. This means these learners were functioning at a level at which they could not perform simple arithmetical operations. Though the performance in Gauteng was also far from being satisfactory, approximately 45% of learners achieved basic numeracy or lower, accounting for 33% fewer than in Mpumalanga. At the top level, Mpumalanga learners performed the lowest of the three groups where fewer than 1% of the leaners achieved at either concrete or abstract levels. In comparison, more than 4% of Gauteng learners achieved at the same levels , thus they were able to identify an unstated problem in order to solve it (Moloi & Chetty, 2010).

4.3 CHARACTERISTICS OF LEARNERS, TEACHERS AND INSTRUCTIONAL STRATEGIES USED IN MATHEMATICS CLASSROOM

In this section, the results of descriptive statistical analysis of characteristics of learners, teachers and instructional strategies used in Mathematics classrooms in Mpumalanga province in comparison to Gauteng and South Africa (SA) overall are presented. This is to determine if there are any similarities or differences in the aspects of teacher instructional strategies and learner achievement in Grade 6 Mathematics for the SACMEQ III project. This sub-section is divided into three parts namely: characteristics of learners in 4.3.1, teacher characteristics and instructional strategies in 4.3.2 and in-school and out of school time in 4.3.3 all of which are the elements of the conceptual framework.

4.3.1 Characteristics of learners

In this section the Grade 6 learners' characteristics in Mpumalanga are described and compared with those in Gauteng and South Africa. The five learner characteristics are: *possessions at learner home, meals received by learners, learner parental educational level, building materials for learner home and English spoken at learner home*. These characteristics also reflect the SES of learners, and as argued in Chapter 3, teachers need to consider them when deciding upon appropriate level of instruction as they may affect how they teach. The characteristics of learners are described and compared below.

4.3.1.1 Possessions at learner home

Learners were asked to indicate which of the 31 household items were available at their households. The responses of learners of Mpumalanga, Gauteng and South African general are summarised in Table 4.3 .

Table 4. 3: Percentage of learners who have specific possessions at home

	Mpumalanga			Gauteng			South Africa		
Possessions	n	%	SD	n	%	SD	N	%	SD
Newspaper	775	63.5	0.48	1562	76.5	0.42	9071	63.2	0.42
Magazine	775	58.7	0.49	1562	74.8	0.43	9071	60.7	0.49
Clock	775	86.5	0.34	1562	88.7	0.32	9071	88.0	0.32
Piped water	775	68.5	0.47	1562	79.1	0.41	9071	61.3	0.49
Bore-hole	775	20.5	0.40	1562	18.7	0.39	9071	17.9	0.38
Table	775	82.5	0.38	1562	87.5	0.33	9071	82.1	0.38
Bed	775	85.0	0.36	1562	90.6	0.29	9071	87.9	0.33
Private study area	775	28.0	0.45	1562	40.8	0.49	9071	33.3	0.47
Bicycle	775	40.4	0.49	1562	43.4	0.50	9071	37.9	0.49
Horse cart	775	11.4	0.32	1562	5.9	0.24	9071	11.6	0.32
Car	775	43.6	0.5	1562	56.7	0.50	9071	44.4	0.50
Motorcycle	775	13.3	0.34	1562	12.2	0.33	9071	10.3	0.30
Tractor	775	14.3	0.35	1562	10.2	0.30	9071	11.2	0.32
Electricity	775	84.6	0.36	1562	94.8	0.22	9071	80.4	0.40
Fridge	775	67.9	0.48	1562	80.7	0.40	9071	66.6	0.47
Air conditioner	775	21.7	0.41	1562	22.8	0.42	9071	17.9	0.38
Electric fan	775	48.7	0.50	1562	59.0	0.49	9071	42.3	0.49
Washing machine	775	37.9	0.49	1562	64.1	0.48	9071	35.5	0.48
Vacuum cleaner	775	22.8	0.42	1562	40.3	0.49	9071	24.6	0.43
Computer	775	24.1	0.43	1562	47.2	0.50	9071	25.1	0.43
Internet	775	16.3	0.37	1562	27.9	0.45	9071	15.7	0.36
Radio	775	90.4	0.30	1562	91.1	0.29	9071	91.3	0.28
Television	775	87	0.34	1562	92.7	0.26	9071	82.6	0.38
VCR	775	40.8	0.49	1562	54.0	0.50	9071	41.4	0.49
DVD/VCD	775	64.4	0.48	1562	79.4	0.40	9071	59.9	0..49
CD payer	775	57.8	0.49	1562	72.5	0.45	9071	56.8	0.50
Cassette player	775	50.1	0.50	1562	54.4	0.50	9071	51.2	0.50
Camera (ord)	775	26.1	0.44	1562	41.1	0.49	9071	29.6	0.46
Camera digital	775	22.2	0.42	1562	34.0	0.47	9071	22.1	0.41
Video camera	775	20.1	0.40	1562	25.6	0.44	9071	18.1	0.38
Phone	775	88.6	0.31	1562	90.9	0.29	9071	88.0	0.33

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In general, learners in Mpumalanga came from homes with fewer possessions than Gauteng but appeared to be similar to learners in general in South Africa overall. Generally, the ownership of the 31 items indicates the type of setting and economic development level of the groups. In Mpumalanga and nationally, the ownership of items used mostly in rural setting was higher, e.g., horse cart. On the other hand, in Gauteng modern (and more expensive) items such as washing machine, computer and Internet were available in a relatively higher percentage of homes. Computers and Internet access can play an important role in learning by allowing learners and teachers to gather the necessary information. Therefore, Gauteng learners had a higher chance of accessing necessary academic information than Mpumalanga learners. Other items, such as telephones and electricity were owned by or accessible to the majority of people across the three groups, and this could be beneficial to the learning process. The findings confirmed Gauteng's wealthier position in general, as measured by the Gross Domestic Product (GDP) per capita (Statistics South Africa, 2013).

4.3.1.2 Meals received by learners

Learners were asked to indicate the frequency with which they had breakfast, lunch and evening meals. The summarised responses of Mpumalanga, Gauteng and South Africa learner participants are presented in Table 4.4 below.

Table 4.4: Percentage of learners receiving meals every day

	Mpumalanga			**Gauteng**			**South Africa**		
	n	%	SD	n	%	SD	N	%	SD
Breakfast	775	69.1	1.06	1562	65.9	1.03	9071	71.6	3.44
Lunch	775	75.7	0.80	1562	82.2	0.69	9071	79.6	3.65
Evening meals	775	81.8	0.80	1562	90.8	0.53	9071	87.3	3.77

On average, learners in Mpumalanga had less access to food than those in the other two groups, with about a quarter not having lunch and almost 20% not eating evening meals daily. With about 31% of learners not having breakfast every day, it is difficult to know if they chose not to or had no food, since an increasing number

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reportedly skip breakfast worldwide (Garriguet, 2007). While the percentages of learners who ate lunch and dinner were high in all the three groups, of serious concern was that not all had regular access to three meals daily. In Mpumalanga, 11% of learners had dinner at irregular intervals, and this could have impacted on the energy needed for engaging in learning activities such as homework. Number of meals per day often reflects the learners 'socio-economic status (SES), which has been shown to relate to learner performance. Parents with high SES can provide all meals to their children (Passos, 2009).

4.3.1.3 Learner parental educational level

Learners were also asked to indicate the level of educational achievement of their mothers and fathers. The questionnaire provided a number of qualifications for learners to select from that matched their parents' educational achievement. Those levels were *no school no adult education*; *no school some adult education; some primary*; *all primary; some training after primary*; *some secondary; all secondary; training after secondary; some university* and *university degree*, The responses of learners are summarised in Table 4.5 below.

Table 4.5 : Percentages of learners reporting on parents' educational level

	Mpumalanga		Gauteng		South Africa	
	Mother %	Father %	Mother %	Father %	Mother %	Father %
No school,no adult education	8	8	3	3	7	5
Some adult education	4	3	1	1	3	3
Some primary	15	11	6	5	11	9
All primary	9	9	9	7	10	7
Some training after Primary	4	3	3	2	3	3
Some Secondary	14	11	17	12	15	12
All Secondary	15	14	20	19	16	15
Training after Secondary	6	8	17	12	9	8
Some University	5	4	6	8	4	5
University degree	7	10	5	13	11	9

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Parents of Mpumalanga learners were less well educated than those in Gauteng and nationally. The most common parental educational level in Mpumalanga was some primary school (see Table 4.5 and Appendix 4.1), indicating that they had not completed primary school level and so this could have impacted negatively on their ability to support their children academically. In Mpumalanga about a third of mothers (36%) and fathers (31%) had achieved less than or up to primary education only and this was substantially different from Gauteng. The most frequent qualification for parents in Gauteng was an “all” secondary school qualification, as indicated in Table 4.5. In general, learner parents’ levels of education were low across the three groups (see Table 4.5 and appendix 4.1 for more information). This is of serious concern since educated parents can give their children good support through provision of atmosphere conducive for learning (Suleman, Aslam, Hussain, Shakir & un-Nisa, 2012).

4.3.1.4 Building materials for learner home

The questionnaire asked learners about the nature of the structure of their family home by specifying the kind of materials used in its construction. The materials concerned were for making floors, walls and roofs. The type of dwelling in which learners live can have an effect on academic performance. Comfortable homes with suitable facilities are an indicator of the SES and can motivate a learner to perform well in academic activities (Moula, 2010). The synopsis of learners’ responses is presented in Figure 4.1.

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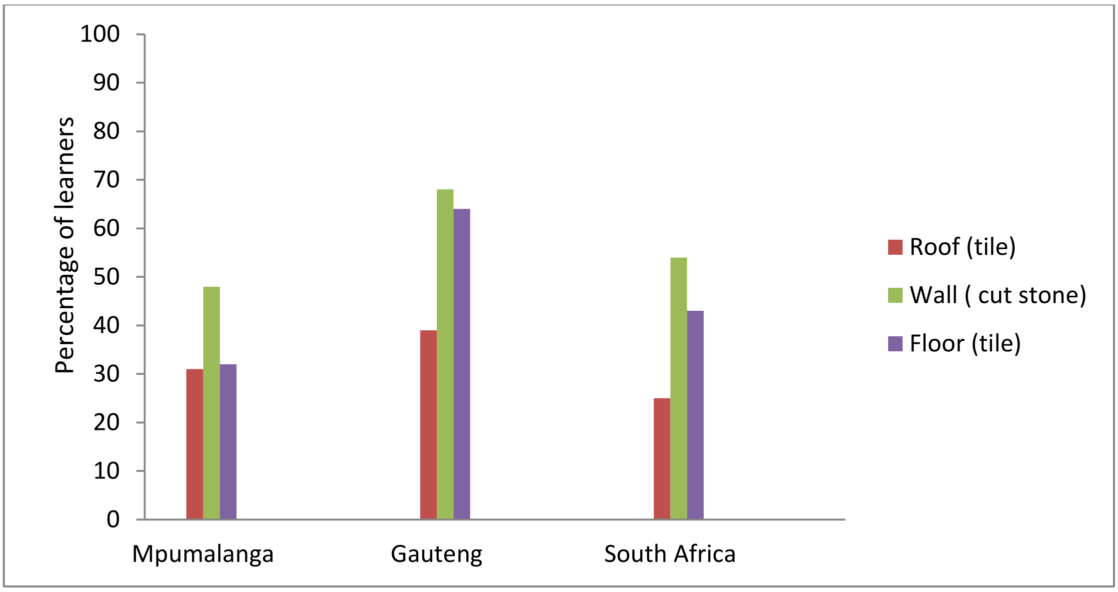

Figure 4.1: Building materials used for learner home

Only 31% of learners in Mpumalanga lived in houses with a tiled roof, this being less than 39% of Gauteng learners but more than learners generally in South Africa (25%). With regard to roof materials, the options on the questionnaire were cardboard/plastic, grass thatch and mud, metal/asbestos, cement and tile. About 43% of learners in Mpumalanga and 52% in South Africa lived in homes with metal roofs. The three materials presented in Figure 4.1 (above) were the most expensive categories available on the questionnaire. For floor material, other options available for learners to choose were earth/clay, canvas, wooden planks and cement. In Mpumalanga, the most common material for floor was cement, while the majority of Gauteng and national learners lived in houses with tiled floors. For wall material six kinds were given as options on the questionnaire, namely, cardboard/plastic, reeds/sticks, mud bricks, wood and bricks. For the three groups the modal wall material was cut stone. However, the percentages for Mpumalanga (48%) and South Africa (54%) were lower than those of Gauteng (68%) (see Appendix 4.1). This serves as a further indication of the differences in economic conditions in the three groups (Statistics South Africa, 2013). In general, the highest percentages of Gauteng learners' homes were constructed from materials that represented the most expensive as compared to the Mpumalanga and the nation. This also reflected the economic development of the three groups, as Gauteng is more developed and urban while Mpumalanga and the country in general are less developed and has large rural areas.

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4.3.1.5 English spoken at learner home

Learners were asked whether they spoke English at home and how frequently. This was an important variable because English is the language of learning and teaching to the majority of learners in South Africa and in SACMEQ, learners wrote the tests in English. Learners were given four options to indicate the regularity with which they spoke the language with their families. The options were *never, sometimes, most of the time* and *all of the time*. The responses of learners are summarised in Figure 4.2 .

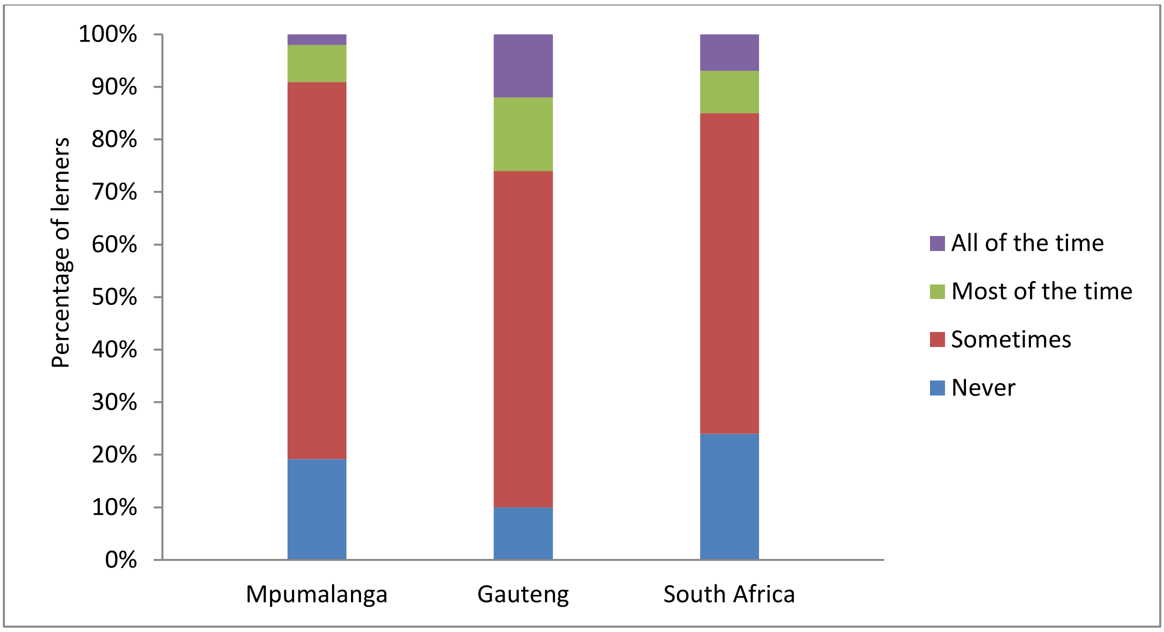

Fig 4.2: Percentages of learners speaking English at home

Mpumalanga had the lowest percentage of learners (2%) who spoke English regularly in their homes compared to 12% in Gauteng and 7% nationally. More than seven in every ten learners in the province (71%) spoke English at irregular intervals (sometimes). This was higher than nationally, in which six of ten learners spoke languages other than English at home. This further indicated that majority of learners were learning in a language that they only sometimes used at home.

In South Africa, English language is one of the two LoLTs and is also often regarded a socio-economic indicator as it is associated with higher status and power. Parents often associate English with improved opportunities in life and want

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their children to be educated in the language (Setati, 2008). However, the frequency with which learners speak the language at home has an impact on their academic performance. Children from families that speak English often have a better chance of performing well in academic activities, so when the LoLT differs from the learner's home language the academic performance tends to be negatively impacted (Howie, 2004). In general, SES can have a significant impact on the educational attainment of learners as children of parents with high SES often achieve good academic results (Suleman, Aslam, Hussain, Shakir & un-Nisa, 2012).

4.3.2 Teacher characteristics and instructional strategies

This sub-section describes the outcomes of data analysis related to factors that as shown previously (see Chapter 2) can contribute to the quality of instruction of mathematics in the classroom. Those factors are *teacher qualifications, teaching experience, teacher gender, teacher age, in-service training and teacher classroom resources*. The analysis of these factors is presented below.

4.3.2.1 Teachers' biographical information

Teachers responded to questions corresponding with their personal and professional information. Table 4.6, Table 4.7 and Figure 4.3 (below) present a summation of this biographical information for Mpumalanga, Gauteng and South Africa.

Table 4.6: Average teacher age and years of teaching information

	Mpumalanga			**Gauteng**			**South Africa**		
	n	Mean	SD	n	Mean	SD	N	Mean	SD
Age	775	40.59	6.84	1562	41.66	9.40	8911	41.12	7.30
Teaching experience	775	14.10	7.84	562	15.48	8.50	8911	15.31	7.73

Mpumalanga teachers were younger and less experienced than those nationally and in Gauteng. A Mpumalanga teacher was on average about one year younger

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than his/her counterpart in Gauteng. Moreover, the experience of teachers in Mpumalanga was also slightly less than in Gauteng and nationally. Perhaps, consistent with the age difference, Gauteng teachers had about one year more experience than their counterparts in Mpumalanga. On the other hand, teacher age in Mpumalanga varied by 26 years whilst nationally and in Gauteng it varied by 42 and 36 years respectively. This further highlights that Mpumalanga teachers were slightly younger, hence the difference in teaching experience (see Appendix 4.1 for further information). Having younger teachers could have offered Mpumalanga learners opportunities to be instructed by teachers with improved qualifications. This is because these teachers were trained after 1994, when the minimum qualification for a teacher was four years' duration. Mpumalanga had a significantly higher proportion of male teachers (29%) than Gauteng and the overall South Africa as implied by the summation in Table 4.7 (below) of percentage of female teachers in each group.

Table 4.7: Percentage of female teachers

Mpumalanga			**Gauteng**			**South Africa**		
n	%	SD	n	%	SD	N	%	SD
740	38.20	0.49	1562	67.10	0.44	9075	54.50	0.49

In Mpumalanga, about 38% of teaching personnel were female, which means the majority of Grade 6 learners were taught by male teachers in this province. This indicates a major change from the situation in 2000, when more than half of Grade 6 teachers were female (Moloi & Strauss, 2005). This might have been because Mpumalanga is a largely a rural province with limited job opportunities. Social services such as education are often the main employers in such areas. Mpumalanga males wanting to stay in the province, might have had to choose teaching due to limited career options. On the other hand, nationally, one in every two teachers was female and Gauteng had the highest percentage of women teachers in Grade 6. Close to seven out of ten Grade 6 teachers were female in this province.

Figure 4.3 presents the qualifications of teachers in the three groups.

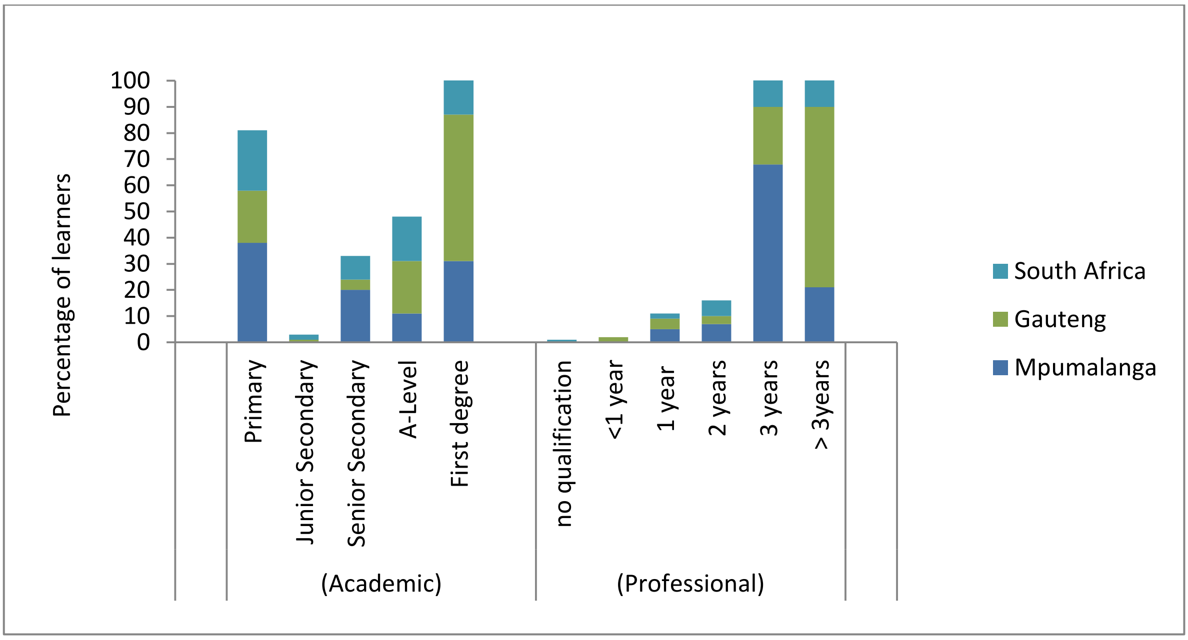

Figure 4.3: Percentage of learners' teachers with an academic degree and three or more years' professional qualification

Generally, teachers in Mpumalanga were less well-qualified than their counterparts in Gauteng and South Africa overall. Questions on qualifications were related to their professional and academic qualifications. The term 'professional qualification' is used to refer to the teaching qualifications while 'academic qualifications' refer to general educational qualifications that are not related to any job.

With regard to academic qualifications, in Mpumalanga the majority of teachers were academically under qualified. About 38% of teachers had a primary school qualification and 20% possessed senior secondary certificate. This means 58% of teachers had equal or lower than senior secondary certificate as their academic qualification. In Gauteng 20% of teachers possessed primary school qualification and 5% possessed secondary school qualifications. This means in Gauteng only a quarter of teaching personnel had secondary school qualification or lower. 31% of Mpumalanga teachers had an academic degree while in Gauteng and the overall South Africa teachers with the same qualification constituted 56% and 48% respectively. Mpumalanga had no universities, therefore students had to travel to provinces such as Gauteng for degree studies.

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Concerning professional qualifications, In Mpumalanga, about 21% had a teaching qualification for which they trained for more than three years. Furthermore, the modal qualification in this province was a three-year course such as Secondary Teachers Diploma (STD) and Primary Teachers Diploma (PTD) which were possessed by 68% of teachers. These courses were presented in teacher training colleges which were closed after 1994. The colleges were concentrated in rural areas such as Mpumalanga which had several of these colleges of education but no university.

In contrast, in Gauteng 69% of Grade 6 teachers had a teacher qualification for which they studied for more than three years. Qualifications such as four-year teachers' diplomas were not available at black colleges of education in the pre-1994 period. In addition, more than 21% of teachers had three-year teaching qualifications. These were Secondary Teachers' Diplomas and Primary Teachers Diplomas which were intended for blacks. This means more than 90% of teachers in Gauteng possessed either a teaching degree or a teaching diploma which may have been reinforced by Gauteng having more universities and teacher training colleges and migration of well qualified teachers to Gauteng from across the country. In Mpumalanga, 5% of teachers had qualifications for which they had trained for one year compared to 4% in Gauteng. For older teachers, these were most likely teaching certificates such as Primary Teachers Certficate and Secondary Teachers Certificate which could be enrolled for after Standard 8 in the pre-1994 period. In the post-1994 era, a one year teaching qualification could have been postgraduate qualifications such as Post Graduate Certificate in Education (PGCE), Higher Education Diploma (HED) or Higher Diploma in Education (HDE) which indicate that the teacher already possessed a degree. The PGCE (as well as HED and HDE) was available to all teachers in 2007 when the SACMEQ III data was collected. Therefore, it is difficult to know the percentage of teachers who had the lower level certificates or those with 1 year higher level certificates. While a teacher with secondary school qualification and one year training can be regarded as under qualified, the same cannot be said about one with a PGCE, though both represent one-year professional training. Nationally, close to half of teachers had a teacher qualification for which they had trained for more than three years. The

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second most popular qualification was a three-year course which was possessed by 39% of teachers.

4.3.2.2 Teacher in-service training

Teachers were asked questions concerning the number of in-service training courses that they had attended, the duration of those courses and their opinions about their effectiveness. The responses of teachers are summed up in Table 4.8 and Figure 4.4 (below).

Table 4.8: In-service training courses

	Mpumalanga			**Gauteng**			**South Africa**		
	n	Mean	SD	n	Mean	SD	N	Mean	SD
In-service training courses	775	2.38	2.18	1562	3.46	4.85	8911	2.97	4.08
Days in in-service training	775	30.18	126.64	1562	11.07	19.83	8911	12.07	43.76

Mpumalanga teachers attended fewer courses but for longer periods of time than those from Gauteng and nationally. Work-related training of teachers is of importance as it can enhance teacher skills and knowledge which can result in improved effectiveness in the classroom (Mogari, Kriek, Stols & Iheanachor, 2009). On average, Mpumalanga teachers attended two in-service training courses per year, which was the least of the three groups. Gauteng teachers attended an average of one more course than their Mpumalanga counterparts. In contrast, the Mpumalanga teachers spent an average of 30 days in training, this amounting to 19 and 18 days more than in Gauteng and nationally respectively.

On the question of how effective they thought the in-service trainings were, teachers' answers ranged on a four-point scale from *not effective* to *very effective*. The responses of those who regarded the trainings as very effective are presented in figure 4.4.

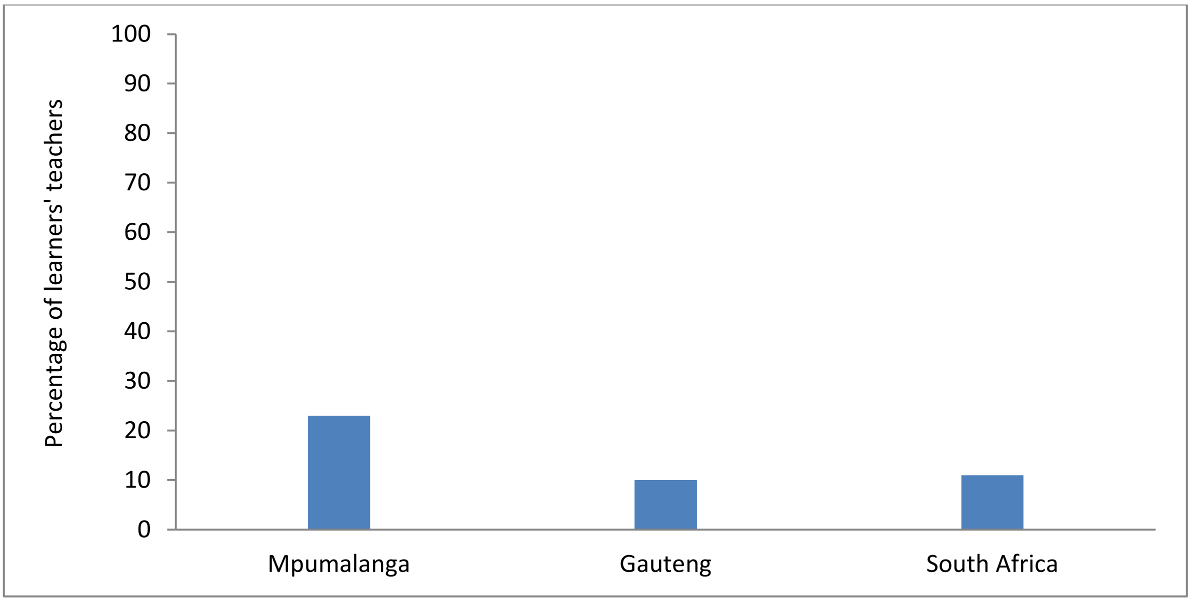

Figure 4.4: Percentage of learners' teachers reporting in-service training as being very effective

More Mpumalanga teachers thought that their courses were very effective compared to the other two groups. This may be in part due to the longer duration of the courses. Twenty- three percent of Mpumalanga teachers considered the training courses *very effective*, the highest of the three groups. This was consistent with the number of days spent in such courses, where Mpumalanga teachers spent the most days and Gauteng the least days of the three groups. This is a concern as in-service training can improve teacher competence and learner achievement (Passos, 2009)

4.3.2.3 Classroom resources

Questions regarding resources used in the Mathematics classroom were asked to teachers and the summary of the responses are presented in Figure 4.5.

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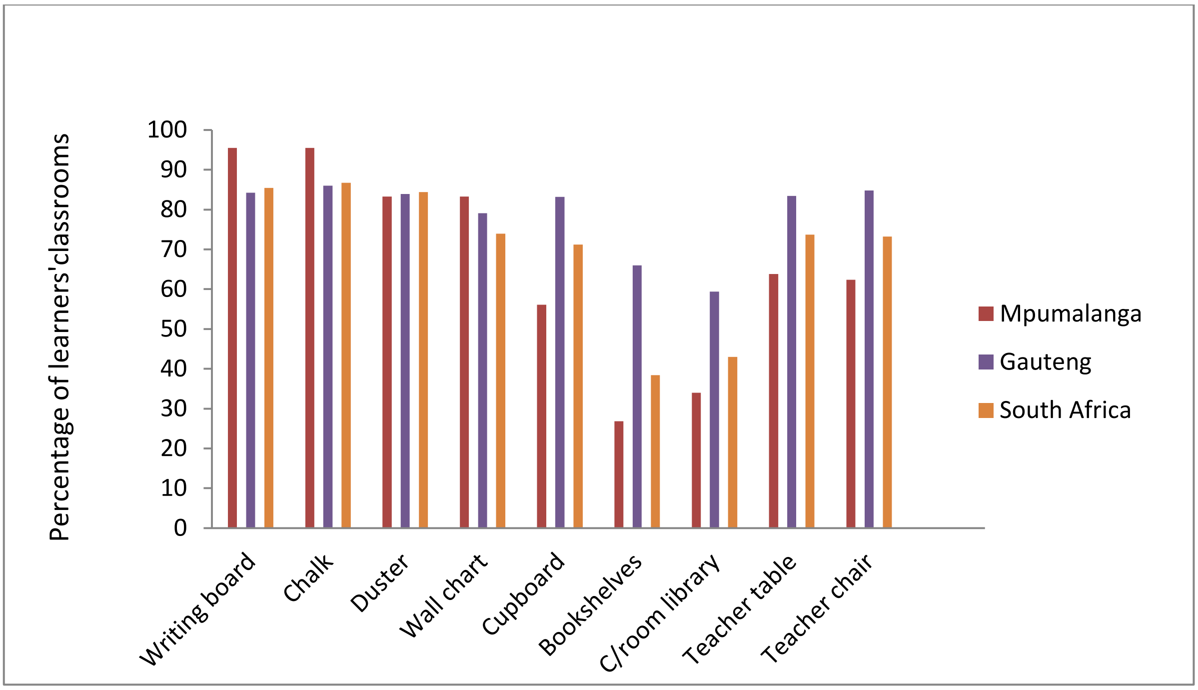

Figure 4.5: Classroom resources

Up to 74% of Mpumalanga learners were in classes that lacked the basic resources for their classrooms. Though chalk, duster and writing board form the core of basic classroom resources, they were not available in some classrooms in the three groups. In Mpumalanga about 5% of learners were in classes with no access to chalk, while in Gauteng about 16% of learners were without a duster. Bookshelves were available in a mere 27% of learners' classrooms in Mpumalanga and only about three in every ten learners had classroom libraries in this province. That suggested that there might have been no books to keep on the shelves, as such the classrooms did not need shelves. Moreover, more than 30% of learners' teachers in Mpumalanga classrooms had no tables or chairs, which could have been a hindrance to the teachers' preparation of their instructional activities. This lack of resources in classrooms is a serious cause for concern since learning can be strengthened when there are material such as books and teaching aids. On the other hand, the available resources still need to be correctly managed for learner performance to improve (Yara & Otieno, 2010).

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4.3.3 In-school and out-of-school time

Under this section factors related to in-school time and learner out-of-school time as part of the conceptual framework (see Chapter 2) are described. In-school time refers to the prescribed time designated by the formal curriculum. The number of teaching periods per week and number of minutes per lesson represent the in-school time, as allocated for instructional activities to take place during school hours.

Learner out-of-school time refers to the time learners spend involved in learning activities outside the classroom for example, in this study, homework characterises learner academic engagement time outside of the classroom.

Figure 4.6 and Table 4.9 (below) give the outlines of responses of Mpumalanga, Gauteng and South Africa' teachers and learners on teacher allocated time for instruction and learner Mathematics homework.

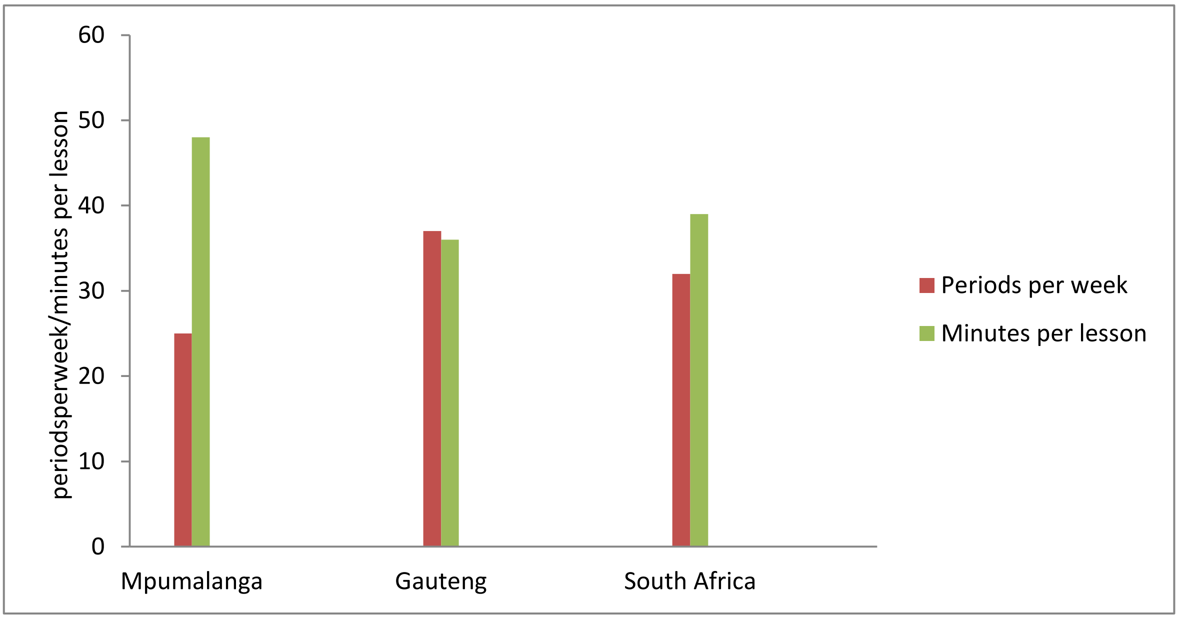

Figure 4.6: Allocated time for formal instruction

Mpumalanga teachers had the fewest teaching periods per week of the three groups but the longest lessons. On average Mpumalanga has 1 200 minutes of teaching time compared to 1 332 minutes Gauteng and 1 248 minutes nationally. The periods were about 14 fewer than at national level, however, these periods were the longest of the three. At about 48 minutes in length, Mpumalanga periods were 12 minutes longer than those in Gauteng. The Revised National Curriculum Statement (RNCS), which directed teaching and learning, stipulated the length of the period as 30 minutes and the number of periods per week as 35 (Department of Education, 2002a). What is surprising is that the time spent on formal teaching varied in the three entities even though they followed the same curriculum policy.

Table 4.9: Percentage of learners receiving homework on most days of the week

	Mpumalanga			**Gauteng**			**South Africa**		
	n	%	SD	n	%	SD	N	%	SD
Homework given	**775**	67.1	0.73	1562	59.5	0.81	9071	56.1	0.79

The question on homework was related to the regularity with which learners received it. Learners were provided with four options to indicate how regularly they received homework if at all.The answer options were: *no homework, once or twice per month, once or twice per week* and *most days*. Mpumalanga learners were given homework more frequently than their peers in Gauteng and nationally. However, at about 67%, it still meant that about 33% of learners were given homework at irregular intervals. This could have been disadvantageous to those learners who needed extra help, because in general homework may be important for inproving performance and for remedial purposes (Cooper, Robinson & Patall, 2006).

Finally, characteristics of learners and teachers and teaching strategies were described and summarised. Mpumalanga learners are living in more deprived circumstances and that teachers and learners are teaching and learning in more difficult and less condusive envrionments and conditions than those in Gauteng and South Africa overall considering the majority of variables analysed above. For example, in Mpumalanga there were relatively poor resources in the classroom and less time on task and learners were of lower SES as indicated by the fact that most learners had less educated parents. Mpumalanga learners may also be more disadvantaged by their lower exposure and usage of English which is the LOLT for most learners in the province compared to Gauteng and nationally.

In the next section the results of correlational analysis between learner characteristics, teacher characteristics and teaching strategies and learner Mathematics score for the SACMEQ III project are described.

4.4 RELATIONSHIPS BETWEEN MATHEMATICS ACHIEVEMENT AND CHARACTERISTICS OF LEARNERS, TEACHERS AND INSTRUCTIONAL EFFICIENCY.

This section contains the results of the Pearson's correlational analysis between the SACMEQ III variables related to teacher instructional efficiency and Grade 6 learner Mathematics scores for Mpumalanga, Gauteng and the overall South Africa (see Chapter 3). Learner characteristics, teacher characteristics and instructional strategies form the independent variables while the learner Mathematics score is the dependent variable.

4.4.1 Characteristics of learners and Mathematics achievement

Characteristics of learners 'relationship with learner achievement are described in this section. Though, the initial number of learner characteristics were five, only those which satisfied the correlational analysis criteria as described in chapter 3.3.3 are presented in this section and used further, unless the variable is found and argued to be of high conceptual value to the study (for the full correlational analysis results for every variable, Appendix 4.2 can be consulted). The relationships between learner mathematics achievement and *possessions at learner home*, *parental level of education, building material for learner home and English spoken at home* in Mpumalanga, Gauteng and South Africa are described below.

4.4.1.1 Possessions at learner home and mathematics achievement

Table 4.10 (below) presents the results of correlational analysis between possessions at learner home and the learner score. Out of 31 possessions at home listed in the learner questionnaire, 23 are reported on since they have satisfied the minimum acceptable correlation analysis criterion of r = 0.20 in at least one of the three groups.

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Table 4.10: Relationship between learner home possessions and learner Mathematics score

	Mpumalanga		Gauteng		South Africa	
	r	Sig. level	*r*	Sig. level	*r*	Sig. level
Newspaper	0.21	0.00	-	-	-	-
Washing machine	0.24	0.00	0.42	0.00	0.46	0.00
Vacuum cleaner	0.26	0.00	0.47	0.00	0.42	0.00
Computer	0.27	0.00	0.44	0.00	0.42	0.00
Internet	0.21	0.00	0.27	0.00	0.29	0.00
VCR	0.20	0.00	0.28	0.00	0.26	0.00
CD payer	0.21	.0.00	0.30	0.00	0.25	0.00
Camera (ordinary)	0.22	0.00	0 37	0.00	0.28	0.00
Camera (digital)	-	-	0.37	0.00	0.30	0.00
Video camera	-	-	0.26	0.00	-	-
Phone	-	-	0.21	0.00	-	-
Electric fan	-	-	0.35	0.00	0.30	0.00
Television	-	-	0.20	0.00	-	-
DVD/VCD	-	-	0.34	0.00	0.30	0.00
Magazine	-	-	0.24	0.00	0.21	0.00
Clock	-	-	0.23	0.00	0.21	0.00
Piped water	-	-	0.24	0.00	0.25	0.00
Bed	-	-	0.23	0.00	-	-
Private study	-	-	0.30	0.00	-	-
Bicycle	-	-	0.29	0.00	-	-
Car	-	-	0.37	0.00	0.27	0.00
Electricity	-	-	0.23	0.00	0.35	0.00
Refrigerator	-	-	0.31	0.00	0.28	0.00

Significance level: 0.05 (2 tailed)

In Mpumalanga, only eight items had positive, though weak relationships with performance. Though weak, the relationships were all significant in being related to learner performance. In Mpumalanga, the highest correlation came from computers. In Gauteng and nationally, washing machine, vacuum cleaner and computer showed a moderate relationship with achievement as opposed to weak association in Mpumalanga. This suggests that learners with items that cost more money, thus requiring higher income were inclined to perform better in Mathematics than those without these items. While Mpumalanga had a positive relationship between

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newspaper and mathematics achievement, in Gauteng and nationally the relationship between the two variables were too weak for consideration. This might indicate that different literacy opportunities and access to information opportunities existed in Mpumalanga and Gauteng. While in Mpumalanga, which is largely rural, families that were inclined to engage in literacy activities tended to buy newspapers, in Gauteng and nationally such families may have had options of using computers and the Internet due to the ease of connectivity in urban areas. Generally, it is not unexpected to see items such as computers and Internet relating positively with learner achievement. Internet can enable learners to have access to information they need for their studies, therefore impacting positively on their performance.

4.4.1.2 Learner parental educational level

The relationship between learner achievement and the educational levels of learners' parent are described below in Table 4.11. As revealed earlier (see Table 4.5 and 4.3.1.3) learners were asked about their parents' educational levels varying from no school to university degree.

Table 4.11: Relationship between learner parental education and learner Mathematics score

	Mpumalanga		**Gauteng**		**South Africa**	
	r	Sig. level	***r***	Sig. level	***r***	Sig. level
Mother education	0.23	0.00	0.36	0.00	0.36	0.00
Father education	0.23	0.00	0.35	0.00	0.30	0.00

Significance level =0.05 (2 tailed)

Significant positive relationships were shown to exist between parents education and learner Mathematics score in Mpumalanga, Gauteng and nationally. This suggests that a learner with more educated parents had a higher probability of achieving higher marks in Mathematics. In Mpumalanga the strengths of relationships were weak as compared to Gauteng, where the associations were of moderate strength. This might be due to the fact that there was less variability in the

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data in Mpumalanga which also had higher proportion of less well educated parents and a much smaller percentage of well educated parents. Gauteng had a wider variation of education levels and and a relatively higher percentage of educated parents. In Mpumalanga, there was no difference between the mother and father' educational level and mathematics achievement while in Gauteng and nationally the association between mothers' educational level and achievement were slightly stronger. This suggests that while in Mpumalanga learners with educated parent were enclined to perform better in Mathematics, the same was true for Gauteng learners with educated mothers.

4.4.1.3 Building material for learner home

The types of materials used to construct learner homes were correlated with their scores in Mathematics test and the results are illustrated in Table 4.12.

Table: 4.12: Relationship between building materials for learner home and learner Mathematics score

	Mpumalanga		**Gauteng**		**South Africa**	
	r	Sig. level	***r***	Sig. level	***r***	Sig. level
Floor materials	0.24	0.00	0.33	0.00	0.28	0.00
Wall materials	0.24	0.00	0.35	0.00	0.31	0.00
Roof materials	-	-	0.31	0.00	0.31	0.00

Significance level= 0.05 (2 tailed)

As explained previously building materials were included in SACMEQ studies as an item for assisting to measure socio-economic status in developing contexts. The Mathematics achievement of Grade 6 learners in the three groups showed significant positive relationships with the two kinds of materials used in building learners' dwellings. This implies that learners who lived in homes made of more expensive materials often performed better in Mathematics than those in homes made of less expensive materials. However, the relationships were weak in Mpumalanga and moderate in Gauteng. With Mpumalanga being a predominantly rural province where the poverty levels are known to be higher (see chapter 1), the likelihood is that the differences in type of dwellings could have been limited. On the contrary, Gauteng being an urban province with the largest GDP in South Africa, could have had homes constructed out of many different kinds of materials. The type of dwelling may have an effect on performance as a comfortable home tends to be conducive for providing good study environment and may be indicative of a home with higher SES including items such as computers, books, Internet and other educational resources. Higher educational levels allow parents to help their children with their studies.

4.4.1.4 English spoken at learner home

The relationship between learner mathematical achievement and the frequency with which English is spoken at learner home was analysed and Table 4.13 (below) presents the results.

Table 4.13: Relationship between English spoken at learner home and learner Mathematics scores

	Mpumalanga		**Gauteng**		**South Africa**	
	r	Sig. level	***r***	Sig. level	***r***	Sig. level
English spoken at learner home	0.18	0.00	0.39	0.00	0.34	0.00

Significance level = 0.05 (2 tailed)

In Gauteng and nationally significant positive associations were shown to exist between learner score and English spoken at learner home. However, in Mpumalanga the relationship was rather very weak and was below the minimum acceptable level of $r = 0.20$. Nevertheless, the coefficient has been accepted since it is of higher conceptual importance to the study. A much smaller proportion of the learners (71%) reported speaking English frequently in Mpumalanga than the other two groups. The positive relationship between English and learner scores suggests that those learners who often speak English have a higher likelihood of scoring higher marks in Mathematics as reported by Howie (2004). This is not unexpected since one of the two languages of learning and teaching in South Africa is English and most learners would be learning in English. Therefore, regular communication in the language can enhance the chances of successful engagement in academic activities.

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4.4.2 Characteristics of teachers and instructional strategies and mathematical achievement.

This sub-section contains the description of the associations between Grade 6 Mathematics score and characteristics of teachers and teaching strategies. Teacher *professional qualifications* and *classroom resources*, *teacher sex, minute per lesson* and *homework given* to learners are the variables whose relationships with learner scores are reported on because their coefficients had satisfied the minimum level of r = 0.20 in at least one of the groups. Teacher characteristics which had correlation coefficients of less than $r = 0.20$ are excluded, namely, *age, years of teaching, academic qualifications and in-service training*. Teaching strategies that did not satisfy the minimum requirement and excluded from this section is *number of periods* (see Appendix 4.2).

4.4.2.1 Teacher professional qualification

The results of correlation analysis between *teacher professional qualifications* were and Mathematics scores are presented in Table 4.14 (below).

Table 4.14: Relationship between teacher professional qualification and learner Mathematics score

	Mpumalanga		**Gauteng**		**South Africa**	
	r	Sig. level	***r***	Sig. level	***r***	Sig. level
Professional qualification	- 0.20	0.00	-	-	-	-

Significance level = 0.05 (2 tailed)

In the SACMEQ teacher questionnaire, professional qualifications measure the number of years a teacher has taken to train for a particular teaching qualification rather than specifying the precise qualification itself. The options included *less than 1 year, 1 year, 2 years, 3 years* and *more than 3 years*. In Mpumalanga, the relationship between professional qualifications and learner performance was significantly negative and very weak. The implication of the negative relationship between professional qualification and achievement is that learners taught by teachers with more years of training were likely to perform worse. The problem with the SACMEQ measurement for the Mpumalanga and South African data is that the 1- year qualification is confounded in the following way, namely: some one year qualifications, such as PGCE, which is a postgraduate qualification from a university, are being classified as lower than a three-year diploma from a teacher training college. However, in reality a teacher with PGCE is more highly qualified than the one with STD. The data seem to suggest that those teachers with fewer years of professional education have learners with higher mathematics achievement in their classes. This could be a reflection of the university trained 1- year postgraduate certificate versus the 3 year trainined college teachers who were numerous in Mpumalanga. Higher teaching qualifications are usually associated with enhancing teacher competence which in turn would be expected to improve the learners' understanding of the subject matter. Generally, learners with highly qualified teachers in Mathematics tend to obtain high marks (Abe, 2014). On the other hand, it might be that these teachers were professionally qualified but not in Mathematics, therefore, their expertise were misplaced. The SACMEQ measurement does not specify the professional qualifications to be specifically mathematics as in some countries, primary education is not specialised along subject lines.

4.4.2.2 Teacher sex

The relationship between *teacher sex* and mathematics achievement of the Grade 6 learners in Mpumalang, Gauteng and South are presented in Table 4.15 below.

Table 4.15: Relationship between teacher sex and Mathematics score

	Mpumalanga		**Gauteng**		**South Africa**	
	r	Sig. level	***r***	Sig. level	***r***	Sig. level
Teacher sex	-	-	0.26	0.00	-	-

Significance level = 0.05 (2 tailed)

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In Mpumalanga and nationally, there was no relationships between teacher sex and mathematics achievement. In Mpumalanga, the ratio of female to male teachers was 1: 1.6 (38:62) which meant for every one female teacher there was about two male teachers and this had no association with learner results. In Gauteng there was positive relationship between teacher gender and mathematical achievement. With about 67% female teachers, this suggests that learners with female teachers often achieved higher results in mathematics.

4.4.2.3 Classroom resources

The associations between *classroom resources* and the scores of Grade 6 learners in Mathematics test are described in the next sub-section.

Table 4.16: Relationship between classroom resources and learner Mathematics score

	Mpumalanga		Gauteng		South Africa	
	r	Sig. level	***r***	Sig.level	***r***	Sig.level
Writing board	- 0.29	0.00	0.21	0.00	-	-
Chalk	- 0.29	0.00	-	-	-	-
Class library	0.25	0.00	-	-	0.21	0.00
Wall chart	-	-	0.25	0.00	-	-
Cupboard	-	-	0.25	0.00	-	-
Bookshelf	-	-	0.33		0.29	0.00
Duster	-	-	0.20	0.00	-	-
Teacher table	-	-	0.21	0.00	-	-
Teacher chair	-	-	-	-	-	-

Significance level = 0.05 (2 tailed)

In Mpumalanga, writing board and chalk showed noteworthy negative associations with achievement. This implies that the more these resources were used the more learners performed lowly in Mathematics. This is unexpected as these resources are the basis of all the resources used for instructional purposes. They are often needed for summarising what has been learned using other resources such as books. However, it may also have been that many of the classroom in Mpumalanga did not have other resources such as classroom library, internet, computers and teacher furniture. Many of these schools were probably poor with the poorest children too. In contrast, in Gauteng six of the nine resources as presented in Table 4.16 above, had significant positive relationships with mathematics achievement. This infers that the more these resources are used the higher the likelihood of learners achieving good mathematics results. This is not surprising, since various resources can complement one another and make the learning process enhanced, for example, the availability of wallcharts in Gauteng classrooms may improve the the learning ability of a visual learner, thus making the teacher' summary on the writing board easy to understand, as opposed to classrooms in Mpumalanga and nationally where most walls were often bare. Furthermore, in Mpumalanga and nationally, classroom library and bookshelf had significant positive association with performance. This indicates that learners with classrooms that offered easy access to various learning materials had a better chance of scoring high marks. This is understandable as variety of books and other learning materials can expose a learner to different ways of studying the subject.

4.4.2.4 Minute per period

The association between *minutes per period of* and mathematics achievement of the Grade 6 learners are presented in Table 4.1.7 below.

Table 4.17 : Relationship between minute per period and Mathematics score

	Mpumalanga		**Gauteng**		**South Africa**	
	r	Sig. level	***r***	Sig. level	***r***	Sig. level
Minute per period	-	-	0.33	0.00	-	-

Significance level = 0.05 (2 tailed)

In Mpumalanga and nationally, the length of the period had no relationship with mathematical achievement. Gauteng was the only one of the three groups where the length of the period had positive association with learner mathematical score. This suggests that the longer the teaching time the higher the probability of learners achieving high mathematics scores. The province had the longest teaching time of the three groups which translated into 132 and 84 more minutes longer than in

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Mpumalanga and South Africa respectively. Perhaps the extra minutes were used positively in guiding learners in their learning of Mathematics.

4.2.2.5 Homework given

The relationship between *homework given* to learners and mathematics achievement are described in the following sub-section.

Table 4.18: Relationship between homework given to learners and Mathematics score.

	Mpumalanga		Gauteng		South Africa	
	r	Sig. level	***r***	Sig. level	***r***	Sig. level
Homework	-	-	0.43	0.00	0.22	0.00

Significance level = 0.05 (2 tailed)

In Mpumalanga, there was no relationship between homework given to learners and mathematics achievement. This is surprising because Mpumalanga had the highest number of learners (67%) who reported to have received homework on most days of the week, however, there was no impact of such homework on achievement. Gauteng and nationally homework had positive relationships with mathematics achievement. This suggests that the more learners received homework, the higher their likelihood of performing well in mathematics. In Gauteng and nationally, perhaps the struggling learners who received homework had their mathematical skill and content knowledge improving, allowing them to improve their scores hence better performances compared to Mpumalanga.

4.5 CONCLUSION

This sub-section has described the results of Pearson's correlational analysis of Mpumalanga, Gauteng and South Africa overall. This was to see if correlations existed between the dependent (mathematics score) and independent variables learner characteristics, teacher characteristics and instructional efficiency). The correlation coefficients indicated that generally in Mpumalanga there learner

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mathematics performance was weakly related to all variables. There were no meaningful associations between mathematical achievement and homework given to learners, length of teaching time, and teacher gender. Where positive relationships occurred, they were weak for example, *English language* and *parental educational level*. In contrast, the relationships between learner achievement and the independent variables were generally weak to moderate in Gauteng and South Africa overall. Only those variables whose relationships with learner scores satisfied the minimum requirement for correlational analysis were included in this chapter. These are: *possessions at learner home, learner parental educational level, building material for learner home, English spoken at learner home* (characteristics of learners), *teacher professional qualification, teacher sex* (characteristics of teachers) and *classroom resources*, *minutes per lesson* and *homework given* (teaching strategies).

Chapter 5 further explores the data further incorporating those variables meeting the requirements as described in this chapter by applying Principal Component Analysis where appropriate and thereafter Hierarchical Multiple Regression Analysis.

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CHAPTER 5:
THE EFFECT OF INSTRUCTIONAL EFFICIENCY ON GRADE 6 MATHEMATICS ACHIEVEMENT

5.1 INTRODUCTION

Chapter 4 presented the findings based on descriptive and correlational analysis of the SACMEQ III variables for instructional strategies and Grade 6 mathematical achievement. This chapter builds on Chapter 4 and addresses the question: What is the effect of instructional efficiency on Grade 6 Mathematics achievement in Mpumalanga in SACMEQ III? In doing so it describes the inferential statistical analysis of the variables related to characteristics of learners and instructional strategies using procedures of Principal Component Analysis (PCA) and Hierarchical Multiple Regressions. The results of the Principal Component Analysis are described in section 5.2 while findings from the Hierarchical Multiple Regression analysis and the concluding remarks are discussed in sections 5.3 and 5.4 respectively.

5.2 EXPLORING COMPONENTS IN PREPARATION FOR REGRESSION ANALYSIS

This section contains the results of Principal Component Analysis (PCA) and reliability analysis conducted on the items that were selected from the SACMEQ III data (see Chapter 3). The new components (factors) formed from the process of PCA were subjected to Cronbach's reliability test for internal consistency (Field, 2009). The variables for PCA are described under components found for characteristics of learners and instructional strategies in 5.2.1 and 5.2.2 respectively.

5.2.1. Components found for characteristics of learners

In this sub-section the results of PCA of items that collectively form characteristics of learners as an element of the instructional efficiency model (see Chapter 2) are described. As explained in Chapter 4 section 4.3.1, learner characteristics are

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factors to consider in teaching and learning situations as they may have an influence on the level at which teachers should instruct their learners. While in Chapter 4 five variables related to characteristics of learners were analysed, only *possessions at the learner home,* as indicated below, was included in the PCA. Variables not considered for PCA were: *building materials for learner home, English spoken at learner home*, *meals for learners* and *learner parental educational level.* 31 variables related to *possessions at learner home* (see Chapter 4.3.1) were analysed. The PCA was done with Orthogonal Varimax rotation (see Chapter 3 for details) and seven components emerged as presented in Table 5.1 below of which the first was substantial.

Table 5.1: Variance explained by possessions at learner home

Components	Initial Eigenvalues			Extraction sum of squared loading			Rotational sum of squared loading		
	Total I	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	6.11	19.72	19.72	6.11	19.72	19.72	3.93	12.67	12.67
2	2.47	7.98	27.70	2.47	7.98	27. 70	2.83	9.12	21.78
3	1.50	4.84	32.54	1.50	4.84	32.54	1.85	5.97	27.75
4	1.44	4.66	37.20	1.44	4.66	37.20	1.75	5.65	33.41
5	1.21	3.90	41.09	1.21	3.90	41.09	1.71	5.50	38.91
6	1.09	3.51	44.60	1.09	3.51	44.60	1.61	5.19	44.10
7	1.00	3.23	47.83	1.00	3.23	47.83	1.16	3.73	47.83

The seven extracted components accounted for more than 47% of the cumulative variance meaning, they share 47% of characteristics that make up the construct of *possession at learner home*. With the exception of piped water, private study area and phone, all other variables had communalities of above 0.40 (see Appendix 5.1), which means that the three variables were rather weakly related to the other 28 variables. This is because a minimum of 40% of shared variance is required to indicate that a variable has a strong relationship to other variables (Field, 2009). The mean communality for the variables was above 0.40 (see Appendix 5.1) so the 31 items were regarded as suitable for the dimension reduction process of PCA (Stevens, 2002). Additionally, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.89. This was well above the level of 0.50 which is regarded as the minimum for PCA. Moreover, Bartlett's test of Sphericity was significant at Chi-square= 4951.07, $p<0.001$. This also indicated that the *possessions* variables were suitable for PCA (Stevens, 2002).

A scree plot was also extracted with the view of presenting the components in a graphical form. Figure 5.1 presents a scree plot with all the 31 components.

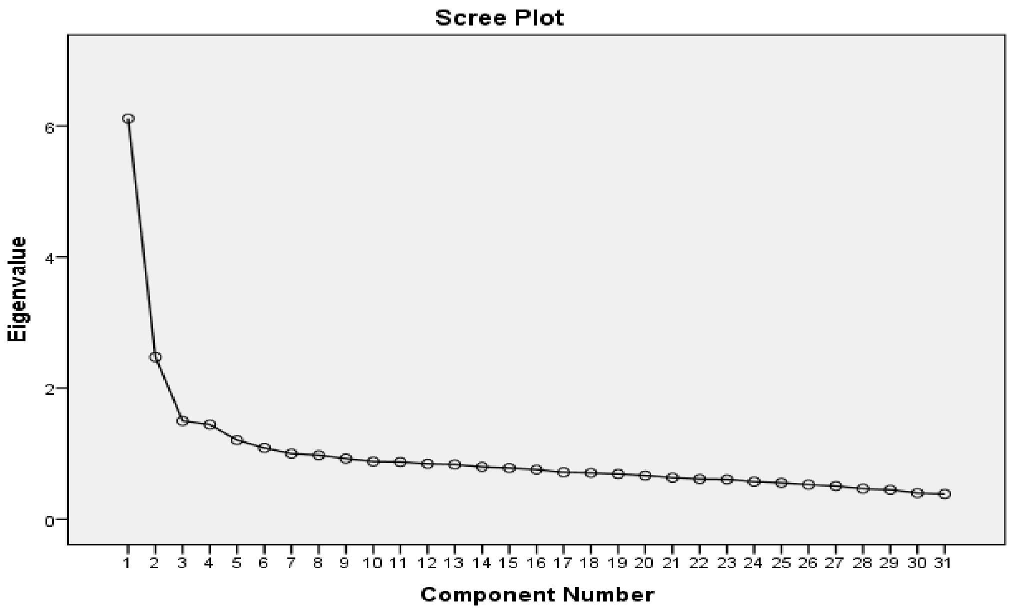

Figure 5.1: Scree plot: Possessions at learner home components

The scree plot shows the relative importance of the 31 components in explaining the construct of *possession at learner home.* Although the scree plot's point of inflexion shows only three components, in reality seven of the extracted variables have satisfied the initial requirement of Eigenvalue of more than one (see Chapter 3 for more discussion on the criteria). Therefore, for further usage in this study the seven components are considered.

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These newly extracted components are presented in Table 5.2 below which shows their original variables as used in the SACMEQ III questionnaire, their new variable name as used in this study and their reliability coefficients.

Table 5.2: Original variables and factors for possessions at learner home

Component	**Original variable name**	**Original variable label**	**Factors**	**Cronbach's' alpha**
1	PPOS11	P/Possession- Car	Convenience	0.81
	PPOS08	P/Possession -Private study	possessions	
	PPOS18	P/Possession -Washing machine		
	PPOS19	P/Possession- Vacuum cleaner		
	PPOS20	P/Possession- Computer		
	PPOS21	P/Possession- Internet		
	PPOS24	P/Possession- VCR		
	PPOS28	P/Possession- Camera (Ord)		
	PPOS29	P/Possession- Camera (digital)		
	PPOS30	P/Possession- Video camera		
	PPOS14	P/Possession- Electricity	Electrical	0.74
2	PPOS15	P/Possession- Fridge	possessions	
	PPOS17	P/Possession- Electric fan		
	PPOS23	P/Possession- Television		
	PPOS25	P/Possession- DVD/VCD		
3	*PPOS03*	*P/Possession- Clock*	*Basic*	*0.45*
	PPOS04	*P/Possession- Piped water*	*household*	
	PPOS07	*P/Possession- Bed*	*possession*	
4	*PPOS26*	*P/Possession- CD player*	*Audio and*	
	PPOS27	*P/Possession- Cassette player*	*communication*	*0.46*
	PPOS31	*P/Possession- Phone*	*possessions*	
5	PPOS10	P/Possession- Horse Cart	Transportation	
	PPOS12	P/Possession- Motorcycle	possessions	0.52
	PPOS13	P/Possession- Tractor		
6	*PPOS01*	*P/Possession- Newspaper*	Media	
	PPOS02	*P/Possession- Magazine*	possessions	*0.48*
	PPOS22	*P/Possession- Radio*	and study	
	PPOS06	*P/Possession- Table*		
7	*PPOS05*	*P/Possession- Bore-hole*	*Bore hole and*	*0.13*
	PPOS09	*P/Possession- Bicycle*	*bicycle*	

Italics = criteria not met

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Cronbach's Alpha's test of internal reliability was undertaken on the initial 31 items and the result was a coefficient of 0.85. This means as a group, these items are acceptable in explaining *possessions at learner home*. The test was further applied on each of the newly extracted components. Items forming *convenience possessions* were highly consistent with one another as indicated by a coefficient of above 0.80. *Basic household, audio and communication* and *media possessions* coefficients are all weak as their coefficients are lower than 0.50, meaning that the items are not addressing the same underlying issues. *Transportation possessions* coefficient of 0.52 was achieved as a result of deleting the item air conditioner from the component. The initial reliability co-efficient was also lower than 0.50. On the other hand, the last component was the weakest as its coefficient was lower than 0.20. This means that the two items were concerned with different issues altogether. All components with a reliability coefficient of less than 0.50 have not been accepted (see Chapter 3 for details). Only three components namely: *convenience possessions*, *electrical possessions* and *transportation possessions* are used further in the study.

To show the relationship between various variables in the seven extracted components a principal component matrix is presented in Table 5.3.

Table 5.3: Component matrix: Possessions at learner home

	Principal Components						
Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Newspaper	0.32	0.05	-0.10	0.15	-0.10	0.54	-0.07
magazine	0.26	0.06	0.01	0.09	-0.10	0.60	-0.04
Clock	0.04	0.05	0.64	0.06	-0.05	0.08	0.10
Piped water	0.18	0.17	0.51	0.02	-0.01	0.00	-0.12
Bore hole	-0.04	0.11	-0.40	0.01	0.37	0.27	0.39
Table	-0.03	0.12	0.29	-0.08	-0.01	0.61	0.10
Bed	0.01	0.20	0.57	0.01	-0.08	0.22	0.29
Private study area	0.38	-0.01	0.07	0.31	0.10	0.26	-0.21
Bicycle	0.33	-0.03	0.16	0.20	0.10	-0.04	0.61
Horse cart	0.06	-0.10	-0.03	0.09	0.65	-0.07	-0.25
Car	0.44	0.18	0.09	0.10	-0.01	0.12	0.39
Motor-cycle	0.26	0.04	-0.05	-0.06	0.61	-0.01	0.07
Tractor	0.04	-0.02	-0.02	0.05	0.70	-0.06	0.15
Electricity	0.01	0.78	0.03	0.02	0.02	0.12	0.12
Refrigerator	0.09	0.63	0.29	0.15	-0.11	0.01	0.08
Air conditioner	0.31	0.27	0.02	0.02	0.34	0.17	-0.38
Electric fan	0.25	0.64	0.20	0.20	0.03	0.09	0.02
Washing machine	0.54	0.48	0.05	0.05	-0.06	0.14	0.03
Vacuum cleaner	0.61	0.29	0.00	-0.02	0.04	0.13	-0.01
Computer	0.65	0.33	-0.05	0.00	0.02	0.15	0.11
Internet	0.63	0.09	0.04	-0.03	0.04	0.08	0.01
Radio	-0.08	0.07	0.33	0.25	0.20	0.45	0.08
Television	-0.00	0.46	0.18	0.45	0.03	0.04	0.05
VCR	0.48	0.31	0.05	0.33	-0.01	-0.03	-0.00
DVD/VCD	0.22	0.54	0.08	0.46	-0.02	0.01	0.12
CD player	0.26	0.34	-0.03	0.64	-0.06	0.12	0.07
Cassette player	0.03	-0.03	0.13	0.64	0.08	0.07	0.08
Camera ordinary	0.60	-0.01	0.19	0.13	0.16	-0.03	0.06
Camera digital	0.65	-0.08	0.10	0.10	0.12	0.03	-0.05
Video Camera	0.64	-0.02	0.02	0.07	0.11	0.06	0.12
Phone	0.04	0.17	0.48	0.32	0.02	0.14	-0.03

Generally, the majority of variables had weak relationships with the seven components. The first component correlated strongly with five of the 31 variables which are camera ordinary, camera digital, vacuum cleaner, computer, and video camera. This indicates that as these variables increase, component one (*convenience possessions*) also increases. One variable which varied strongly and positively with Component two was electricity. This suggests that the ownership of electrical possessions were more likely where there was an increased availability and ownership of electricity. Furthermore tractor had the strongest relationship with

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component five. This indicates that the increased availability of this possession shows transportation possessions increase.

5.2.2 Components found for Instructional strategies

This sub-section contains the results of PCA conducted on the SACMEQ III variables that are related to classroom resources as possible factors that can impact on quality of instruction. Classroom resources can have an impact on the quality of instruction (Kurdiziolek, 2011). *Classroom resources* was not the only variable related to the conceptual element of quality of instruction but, was the only one appropriate for the PCA (see Chapter 4.3.2).

Principal Component Analysis was conducted on the initial eight variables that formed the construct of teacher classroom resources and analyses revealed three components which are presented in table 5.4 below.

Table 5.4: Variance explained by variables related to classroom resources

Components	**Initial Eigenvalue**			**Extraction sum of squared loading**			**Rotation sum of squared loading**		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	3.48	38.65	38.65	3.48	38.65	38.65	2.93	32.56	32.56
2	1.94	21.54	60.19	1.94	21.54	60.19	2.12	23.52	56.08
3	1.27	14.10	74.29	1.27	14.10	74.29	1.64	18.21	74.30

The extracted components account for more than 70% of the cumulative variance for explaining *teacher classroom resources.* Moreover, the rotational process improved the distribution of variance among the variables and thereby resulted in

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the cumulative sum of square loading increasing by one point to 74.3%. This shows that the variables were sufficient for explaining the construct of classroom resources. Though the communality for item *cupboard* was less than the minimum acceptable level of 0.40, the average item communality was more than 0.70 which clearly indicated that the variables shared common variance (see Appendix 5.1). Although, the criteria of the KMO of at least 0.50 and Bartlett's test of Sphericity were not satisfied, the results of PCA were accepted as the Eigenvalue of 1 and the average communalities of more than 0.40 were sufficient criteria for accepting the results of the PCA (Stevens, 2002).

Furthermore, a scree plot was extracted to give a graphical representation of components and it is shown in Figure 5.1 below.

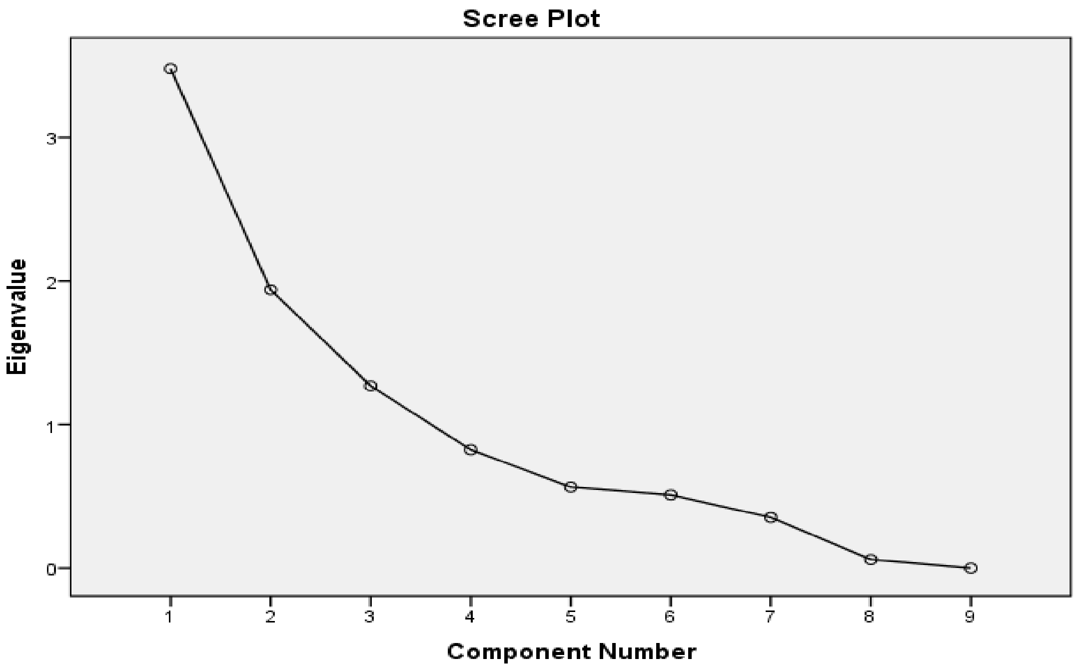

Figure 5.2: Scree plot: classroom resources components

The scree plot shows that the first component had an Eigenvalue of more than 3 which is considerable while the second and the third components also had values of above one. In Table 5.5 the new components, their variable name as used in the SACMEQ study, the name as used in the current study and Cronbach's alpha reliability coefficients are presented.

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Table 5.5: Original and factors related to classroom resources

Components	Variable name	Variable label	Factors	Cronbach's alpha
1	YRESCKBD YRESCHLK YRESDSTR YRESWCHT	T/Class Res-Writing board T/Class Res-Chalk T/Class Res-Duster T/Class Res-Wall chart	Teaching aids	0.80
2	YRESTTAB YRESTCHR	T/Class Res-Teacher table T/Class Res-Teacher chair	Teacher furniture	0.96
3	YRESCPBD YRESCLIB YRESBKSH	T/Class Res-Cupboards T/Class Res-Library T/Class Res-Bookshelf	Classroom furniture and library	0.54

The variables were analysed for internal consistency using Cronbach's alpha test of reliability. The reliability coefficient of α = 0.74 was obtained from the analysis of the initial nine classroom resources variables. Individually each component satisfied the criteria for further analysis. Component one had a reliability coefficient of α = 0.80 which is regarded as good (Field, 2009) for measuring the construct of teaching aids in the classroom. On the other hand, the coefficient for the third components was α = 0.54 which is regarded as weak (Kaizer,1960) but accepted since it meets the minimum criteria (see Chapter 3) and the variable are conceptually strong for addressing the issue of classroom resources.

To show the relationship between various variables in the seven extracted components a principal component matrix is presented in Table: 5.6.

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Table 5.6: Principal component matrix: classroom resources

	Principal components		
Variables	**1**	**2**	**3**
Writing board	0.93	0.21	-0.11
Chalk	0.93	0.21	-0.11
Duster	0.80	-0.21	0.20
Wall chart	0.63	0.25	0.24
Cupboard	0.29	0.28	0.46
Bookshelf	0.17	0.23	0.80
Classroom library	-0.22	-0.40	0.82
Teacher table	0.12	0.94	0.18
Teacher chair	0.11	0.95	0.12

The *writing board*, *chalk, duster* and *wall chart* all loaded strongly onto Component one. *Teacher table* and *chair* loaded very strongly and positively on Component two. *Cupboard*, *bookshelf, class library* loaded on component 3 fairly strongly. This indicates that as these variables change, component three also changes in the same direction.

In the next sub-section, the components which were extracted from the process of PCA and met the criteria (see Chapter 3) are used in the building of Hierarchical Multiple Regression models for Mpumalanga, Gauteng and South Africa. The other independent variables that were not part of PCA are also included in the building of the regression models based upon Mpumalanga correlational analyses results. Those variables are: *learner mother educational level, learner father educational level, wall materials for learner home, floor materials for learner home, English spoken at learner home and teacher professional qualifications*.

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5.3 HIERARCHICAL MULTIPLE REGRESSIONS

The aim of this study is to investigate the effect of instructional efficiency on Grade 6 mathematical achievement. A Hierarchical Multiple Regression analyses were performed to see if the independent factors could predict the mathematical achievement of Grade 6 learners with a high level of accuracy. The reason for using hierarchical multiple regressions were to examine the effects of a number of predictor variables as guided by findings in past research (Field, 2009). The predictor variables are related to SES and school environment. A number of researchers such as Maswikiti (2008) and Burney and Beilke' (2008) findings were that socioeconomic status has higher impact on learner achievement than school related factors. Therefore, variables that are related to characteristics of learners were used as first level predictors and characteristics of teachers and instructional strategies as level two predictors. This means by placing SES related predictors in the first model, the contributions of these factors on learner performance was accounted for first. Therefore, the second model shows the variance explained by instructional strategies after differences attributable to SES factors have been considered. This clarified the difference that classroom level factors brought to learner performance. Learner mathematical score for the SACMEQ III study was used as the criterion variable.

From the results of Principal Component Analysis, all the new components with a reliability coefficient of ≥0.50 were used as predictor factors. Based upon Mpumalanga results, all other independent variables which were not subjected to PCA but had correlation coefficient of at least $r = 0.20$ were also included in the creation of the Hierarchical Multiple Regression models for the three groups (Chapter 3 for details). The total initial number of predictor factors considered was eleven and they are presented in Table 5.7.

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Table 5.7 Variables entered for Hierarchical Multiple Regression model building

Conceptual framework	Adapted conceptual framework	Factor name	Variables	PCA
Appropriate level of instruction	Characteristics of learners	Convenience possessions	Private study, car, washing machine, vacuum cleaner, computer, internet, VCR, camera (Ord),camera (digital),video camera	Yes
		Electrical possessions	Electricity, fridge, electric fan, Television, DVD/VCD	Yes
		Transportation possessions	Horse Cart, motorcycle, tractor	Yes
		Floor material	Earth or clay, canvas, cement wooden plank ,tiles	No
		Wall material	Cardboard, grass, mud bricks stones, wood, metals, bricks	No
		Learner mother education Learner father education	No school no adult education, No school some adult education, Some primary, All primary, Some training after primary Some secondary, All secondary, Completed training after secondary Completed some university completed university degree	No
		English language	None	No
Quality of instruction	Teacher characteristics	Teacher training	No training <1 year training 1 year training 2 year training 3 year training > 3 year training	No
	Teaching strategies	Classroom furniture and library	Cupboards Classroom library Bookshelf	Yes
		Teaching aids	Writing board Chalk Duster Wall chart	Yes

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Factors were entered as predictors and learner score as dependent (criterion) variable. The correlation matrix revealed that independent variables were not highly correlated which indicated that they were suitable for multiple regression analysis. The tolerance statistic for all predictors was above the minimum level 0.50, thereby indicating that there was no multi-collinearity between predictor variables (Stevens, 2002).

In Mpumalanga, *English spoken at learner home, electrical possessions, mother educational level, father educational level and floor material for learner home* made non-significant contributions to the hierarchical regression model, as such they were removed as predictors. Therefore, only six factors were eventually used as predictors. The Hierarchical Regression Analysis was undertaken in two stages. For the first model, the predictors were *convenience possessions*, *transport possessions and wall materials for learners' homes.* These were SES related predictors and as explained above they had to be accounted for first as their impact on learner performance tended to be large. Model *2* comprised predictors that formed model one with the addition of the *classroom furniture and library, teacher training* and *teaching aid (*refer Table 5.7*).* Therefore, the regression equation for Mpumalanga is:

$Y_i = b_0 + (b_1x_{1i} + \ldots b_6x_{6i}) + \varepsilon_i$

Learner achievement $_i$ = *Constant* + *(*b_1*ConveniencePossessions)*

+ (b_2 *TransportPossessions*) + (b_3 *WallMaterialforLearner'Home*$_i$*)*

+ *(*b_4*ClassroomFurnitureAndLibrary*$_i$*)* + *(*b_5*TeacherProfessionalQualification)*

+ ***(***b_6*TeachingAcids)* + ε_i

In Gauteng, *teaching aids* and *teacher professional qualifications* and *floor material for learner homes* made non- significant contributions to the model as such were removed and the regression analysis was rerun. Therefore, the first stage comprised SES factors namely: *convenience possessions, electrical possessions, transport possessions, wall material for learner home, English spoken at learner home, mother educational level and father educational level* which were all significant at $p \leq 0.05$. In addition to the predictors entered in step one, *classroom furniture and library* was entered as predictor variable in model two. This brought the total predictor variables to eight (see Table 5.8). Therefore, the hierarchical regression equation for Gauteng is as follows:

$Y_i = b_0 + (b_1 x_{1i}) + \ldots (b_8 x_{8i}) + \varepsilon_i$

Learner achievement =

Constant + (b_1 ConveniencePossessions $_i$) + (b_2ElectricalPossessions)

+ (b_3TransportationPossession$_i$) + (b_4WallMaterialforLearner'Home$_i$)

+(b_5EnglishSpokenATLearnerHome$_i$)+(b_6LearnerMother'LevelOfEducation$_i$)

+ (b_7LearnerFather'sLevelOfEducation$_i$)+(b_8ClassroomFurnitureAndLibrary$_i$)+ ε_i

In South Africa, like in Mpumalanga, *electrical possessions* were a non-significant predictor of learner achievement, therefore it was removed and the analysis was repeated. The first model comprised the following predictor variables: *convenience possessions, transport possessions, wall material for learner home, floor material for learner home, English spoken at learner home, learner mother level of education and learner' father level of education.* Model two comprised all predictor variables for model one and included the *classroom furniture and library, teaching aids* and *teacher training* all of which are significant predictors of learner achievement. Thus, the regression equation for the overall South Africa is as follows:

$Yi = b_0 + (b_1 x_{1i}) + (b_2 x_{2i}) + \ldots (b_1 0x10_{i.}) + \varepsilon_i$

Learner achievement$_i$ =

Constant + (b_1 ConveniencePossessions $_i$) + (b_2TransportationPossessions$_i$)

+(b_3WallMaterialForLearner'sHome$_i$)+(b_4FloorMaterialForLearnerHome$_i$)

+(b_5EnglishSpokenAtLearnerHome$_i$)+(b_6LearnerMotheEducationalLevel$_i$)

+(b_7LearnerFatherEducationalLevel$_i$)+ (b_8ClassroomFurnitureAndLibrary$_i$)+

+(b_9TeacherProfessionalQualification$_i$) + (b_{10}TeachingAids$_i$) + ε_i

5.3.1 Model and ANOVA summaries

The results of the Hierarchical Multiple Regression analyses for Mpumalanga, Gauteng and South Africa are presented in Table 5.8.

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Table 5.8: Model and ANOVA summaries for Mpumalanga, Gauteng and South Africa

	Models	R	R^2	R^2 change	df 1	df 2	Sig. change	F-ratio	Sig. level
Mpumalanga	1	0.46	0.21	0.21	3	864	0.000	76.82	0.000
	2	0.52	0.27	0.06	3	861	0.000	53.01	0.000
Gauteng	1	0.65	0.42	0.42	7	1009	0.000	105.04	0.000
	2	0.66	0.43	0.01	1	1008	0.000	94.45	0.000
South Africa	1	0.58	0.34	0.34	7	8859	0.000	637.80	0.000
	2	0.59	0.35	0.01	3	8856	0.000	475.70	0.000

Overall, across the three models, the SES related factors explain most of the variance while very little is explained by the classroom related factors. On average, in Mpumalanga 6% and about 1% of variance in Gauteng and South Africa are explained by the classroom related factors. For Mpumalanga, the model summary (R) indicates that the predictor variables included in the models have a positive relationship with learner mathematical scores. The R coefficient of 0.52 ($p < 0.001$) indicates that the predictor variables' relationships with learner scores were weak. Thereby, the implication is that the variables tended to give a weak prediction on learner achievement. R^2 indicates that a mere 27% in variability in learner score was accounted for by the predictors. The ANOVA's F- ratio indicates that model two had an increased ability to predict learner performance (see Appendix 5.2). This is because the model includes more predictor variables than model one; hence it explains more variance than the former model. Model 2 was statistically significant. The addition of *classroom furniture and library*, *teacher professional qualification* to the prediction of learner score (Model 2) increased the variance in the learner scores by 6% ($R^2 = 0.06$, $F\ (3,861) = 23.26$, $p < 0.0001$).

In Gauteng, the model two summary (R) shows that in general the predictor variables had positive relationships with learner scores. The association between these predictor variable and learner score as indicated by the R coefficient of 0.66 was moderate. This implies that the model tended to give a moderate prediction of factors that could impact on learner achievement. The R^2 indicates that 43% of variability in learner performance was explained by the predictors. The ANOVA F ratio (94.45) ($p < 0.0001$) indicates that the second model was better than the preceding one at predicting the learner outcome. Model 2 was statistically significant, R^2 = 0.43, F (1, 1008) = 94.45, $p < 0.0001$; adjusted R^2 = 0.42. The addition of classroom level factors to the prediction of learner score (Model 2) led to a statistically significant increase in R^2 of 0.01, F (1, 1008) = 12.16, p = 0.001 (see Appendix 5.2 for more information).

For the overall South Africa, the model summary (R) indicates that generally the predictor variables had positive relationships with learner achievement. The strength of these relationships as represented by the (R) value of 0.59 was considered weak. This means that the model explains about 35% of the total variance for learner achievement. Furthermore, this means about 65% of learner performance variance is explained by other factors. The F-ratio of 475.70 p < 0.001 also indicated that the second model was better at predicting the performance of learners. Model 2 was statistically significant, R^2 = 0.35, F (3, 8856) = 475.70, p < .0001; adjusted R^2 = 0.35. The addition of *classroom furniture and library*, *teacher professional qualification* and *teaching aids* to the prediction of learner score (Model 2) led to a statistically significant increase in R^2 of 0.01, F (3, 8856) = 65.15, p = 0.001 (see Appendix 5.2).

5.3.2 Coefficients of the regression models

The unstandardised, standardised coefficient B values and predictor variables for Mpumalanga Gauteng and South Africa models are presented in the tables below. The unstandardised B value is an indicator of the individual contribution of every predictor variable in a model while the standardised B value indicates the number of standard deviation that the mathematical achievement will change per every standard deviation change in the predictor variables (Field, 2009). In other words, the unstandardised B value shows the extent to which each predictor variable influences learner achievement if all other predictors were kept constant. Moreover, the t-test value indicates whether a particular predictor variable makes a substantial contribution to the model or not. As for the constant, it represents the value of mean for the dependent variable when all predictor variables are of the value of zero (Field, 2009).

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Table 5.9: Coefficients of the regression models: Mpumalanga.

Models	Unstandardised coefficients B	SE	Standardised coefficients B	t- test	Sig. level
Model 1					
Constant	8.96	1.16		7.71	0.000
Convenience possessions	0.80	0.07	0.38	12.01	0.000
Transportation possessions	-1.71	0.25	-0.23	-7.22	0.000
Wall material for learner home	0.63	0.11	0.17	5.65	0.000
Model 2					
Constant	20.17	2.31		8.72	0.000
Convenience possessions	0.61	0.07	0.29	8.99	0.000
Transportation possessions	-1.57	0.24	-0.20	-6.76	0.000
Wall material for learner home	0.56	0.11	0.16	5.25	0.000
Classroom furniture and library	1.00	0.18	0.17	4.48	0.000
Teacher professional qualifications	-0.92	0.24	-0.11	-3.80	0.000
Teaching aids	-1.14	0.19	-0.19	-5.95	0.000

In Mpumalanga, neither SES nor instructional strategy predictors made a large contribution to learner score. Concerning SES predictors, the unstandardised B values show that positive relationships existed between learner score and *convenience possessions* and *wall materials* used for learner' homes. However, the greatest contribution came from *transportation*, and this was negative, which suggests that ownership of *donkey cart* and *tractors* had a negative relationship with learner score. Learners coming from households owning donkey carts and tractors tended to achieve lower scores than those who did not. The ownership of such items was linked to reduced learner achievement by 1.57 (SE=0.24) points. The t-test results of these predictor variables also indicated that their contributions to learner performance were significant.

From instructional strategy predictors, only *classroom furniture and library* contributed positively to learner performance. The unstandardised B values show that the availability of *classroom furniture and library* were linked to an increase in learner score by 1.00 (SE = 0.18) points. In contrast, *teaching aids* and *teacher professional qualifications* had negative relationships with mathematical achievement. This implies that learners learning in classes with a chalk, duster and writing board and who were taught by teachers with lengthier teaching qualifications often performed poorly. Longer *teacher professional qualification* was linked to a reduction of learner score by 0.92 (SE = 0.24) points. At face value this finding may seem surprising since longer professional qualifications may be expected to improve the proficiency of teachers in the subject. However, in the SACMEQ teacher questionnaire, the professional qualifications measured the number of years a teacher spent training for a particular qualification (see Chapter 4). This would impact negatively on the South African situation with its differentiated teacher qualifications and apartheid history. Therefore, in the SACMEQ data some undergraduate qualifications such as Primary Teachers' Diploma (PTD) were higher on the scale than shorter qualifications, that is, postgraduate qualifications such as PGCE, for which one would have had to have an undergraduate degree rather than college diploma. While a PTD was studied for three years, it was a lower qualification than PGCE which is studied for one year (see Chapter 4). Therefore the wording in the SACMEQ questionnaire was not suitable in capturing the nuances in the South African teacher training landscape and this seemingly negative result should not be taken at face value as higher number of years spent in teacher training in the South African context does not necessarily mean a teacher is more qualified.

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Table 5.10 Coefficients of the regression models: Gauteng

Models	Unstandardised coefficient B	SE	Standardised coefficient B	t- test	Sig. level
Model 1					
Constant	-3.04	1.68		-1.81	0.007
Convenience possessions	0.81	0.77	0.34	10.62	0.000
Electrical possessions	0.61	0.18	0.10	3.34	0.001
Transportation possessions	-1.09	0.30	-0.09	-3.58	0.000
Wall material for learners home	0.70	0.13	0.13	5.14	0.000
English spoken at learner home	1.85	0.24	0.20	7.71	0.001
Mother education	0.28	0.08	0.10	3.46	0.001
Father education	0.17	0.06	0.08	2.65	0.008
Model 2					
Constant	- 4.91	1.76		-2.80	0.005
Convenience possessions	0.75	0.08	0.31	9.58	0.000
Electrical possessions	0.57	0.18	0.09	3.13	0.000
Transportation possessions	-1.10	0.30	-0.09	-3.66	0.000
Wall materials for learner home	0.62	0.14	0.12	4.48	0.000
English spoken at learner home	1.87	0.24	0.20	7.84	0.000
Learner mother education level	0.27	0.08	0.10	3.47	0.000
Learner father education level	0.17	0.06	0.08	2.70	0.007
Classroom furniture and library	0.70	0.20	0.09	3.49	0.000

Sig level 0.05 dependent variable= Mcorp (Learner score)

In Gauteng, SES factors contributed more predictors than the classroom level factors to model 2. The largest contribution came from *English spoken at learner home* followed by *convenience possessions* at learner home. The unstandardised B values of the second model show that *English spoken at learner home* was linked to an increase in learner score by 1.87 points. The implication is that the more learners speak the English language, the better their chances of achieving high score in Mathematics. This is not surprising since learners who speak the language at home often have a good understanding of it. English is one of two LoLTs at Grade 6 in South Africa and a good command of the language can give a learner a chance to better engage in academic activities. The second largest contributor was *convenience possessions* which were linked to an increased learner score by 0.75. On the other hand, ownership of t*ransportation possessions* such as donkey cart were linked to a decreased learner achievement by 1.10 (SE=0.25). In Mpumalanga, learner mother and father educational level were predictors of learner performance, However the contributions were very weak. This might have been that very few parents had gone to school consequently, there was little variation. The type of dwelling contributed significantly to learner outcome, as shown by unstandardised B value of 0.62 (SE=0.14) for wall material. Their positive relationship with learner outcome suggests that learners who live in homes built with more expensive materials are likely to achieve higher scores possibly because this is also an indication of high socioeconomic status. Learners from high SES background may have access to other facilities that can improve their learning (Maswikiti, 2008).

From classroom level predictors, only *classroom furniture and library* were included in model 2, and these contributed 0.70 (SE=0.20) points to learner score. Resources such as books are important to the process of learning and teaching, therefore classroom libraries provide learners with information that can expand their knowledge needed to understand the subject content. Furthermore, critical reading skills can be developed when learners are often exposed to reading. Over time, this can lead to improved learner achievement (Young, Moss & Cornwell, 2007).

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Table 5.11: Coefficients of the regression models: South Africa

Models	Unstandardised coefficients B	SE	Standardised coefficients B	t- test	Sig. level
Model 1					
Constant	2.43	0.45		5.43	0.000
Convenience possessions	0.83	0.03	0.34	31.94	0.000
Transportation possessions	-1.31	0.10	-0.12	-13.24	0.000
Wall material for learner home	0.52	0.04	0.12	12.12	0.000
Floor material for learner home	0.36	0.06	0.06	5.98	0.000
English spoken at learner home	1.38	0.08	0.15	16.37	0.000
Learner mother educational level	0.29	0.03	0.13	11.59	0.000
Learner father educational level	0.10	0.02	0.05	4.70	0.000
Model 2					
Constant	0.54	0.71		0.76	0.45
Convenience possessions	0.76	0.03	0.31	29.35	0.000
Transportation possessions	-1.25	0.10	-0.11	-12.70	0.000
Wall material for learner home	-0.47	0.04	0.11	11.07	0.001
Floor material for learner home	0.30	0.06	0.05	5.05	0.000
English spoken at learner home	1.30	0.08	0.15	15.60	0.000
Learner mother educational level	0.27	0.03	0.12	-11.03	0.000
Learner father educational level	0.20	0.02	0.05	4.43	0.000
Classroom furniture and library	0.91	0.07	0.14	13.33	0.000
Teacher professional qualifications	0.25	0.08	0.03	3.27	0.01
Teaching aids	-0.30	0.05	-0.06	-5.71	0.000

Sig level 0.05 dependent variable= learner score

For South Africa overall, neither SES nor instructional strategies predict learner mathematics performance strongly. Out of the SES predictors, the greatest contributor to learner score was *English spoken at learner home*. The variable was linked to an increase in learner achievement by 1.30 points, which suggests that learners who spoke English at home often performed better than those who did not.

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This was not surprising because such a learner would be able to understand the academic language used in class. *Transportation possessions* were linked to a decrease of 1.25 (0.10) points. From classroom level predictors, *classroom furniture and library* were linked to an additional 0.91 (SE=0.07) points on learner performance. This explains that availability of such resources may have a positive impact on learner results.

In comparing the three groups' models given control of background variables, it was evident that in all of the models, SES related variables contributed relatively more than the instructional strategy variables to the learners' mathematics score. In Mpumalanga, six of nine predictors were included in the second model. English language, learner parents' education level, type of dwelling for learner family and electrical possessions were not predictors of learner mathematical performance in this province. In contrast, in Gauteng teacher training and teaching aids were excluded from the models as their predictions of learner achievement were non-significant. This indicated that variables that were not predictors in Mpumalanga were found to be predictors in Gauteng. In South Africa the model was the largest of the three units as it included eight of nine predictors. Only electrical possessions were not predictors of the learner performance in mathematics.

5.4 CONCLUSION

This chapter has described the results of inferential statistical analysis of Mpumalanga, Gauteng and the national data. Since the number of items related to certain variables were too high for inclusion in multiple regressions, PCA was employed to reduce the volume of the data while still retaining as much of the original information as possible. Variables related to *possessions at learner home* were reduced from 31 to seven factors while nine variables related to classroom resources were reduced to three factors. The hierarchical multiple regressions were used to examine the degree of accuracy with which the independent variables could predict the Grade 6 mathematical achievement in the three groups. The predictor variables were divided into two groups namely: SES and instructional strategies. The findings were that neither of the two groups of variables had contributed largely to learner performance. In Mpumalanga and Gauteng only 27% and 35%

respectively, of variances in learner performance were explained by predictor variables.

CHAPTER 6:
SUMMARIES, CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter presents summaries, conclusions and recommendations of the study to investigate the effect of instructional efficiency on Grade 6 learners' Mathematics achievement in Mpumalanga in the SACMEQ III project. It is divided into five sections: summary of research process (6.2), summary of the research findings (6.3), reflection on methodology (6.4), reflection on the conceptual framework (6.5), main conclusions (6.6), recommendations for further research, policy and practice (6.7) and conclusion for the study (6.8).

6.2 SUMMARY OF THE RESEARCH PROCESS

This study was a secondary data analysis of the SACMEQ III cross-sectional study which was undertaken in 2007 under the auspices of UNESCO and managed by the IIEP. South Africa was one of 15 countries taking part in the study that mainly focused on Mathematics and Reading at Grade 6. This research utilised SACMEQ III data in a secondary analysis design. The data was collected from learners and teachers by the SACMEQ national coordinating centre in each country and in South Africa, this was the DBE. Nationally, a total of 9 071 learners from 392 schools were involved in the study. This included Mpumalanga's 775 learners from 38 schools and 1 562 learners in 78 schools in Gauteng.

The data comprised Mathematics test scores collected from learner Mathematics assessments written in English and information from learner questionnaires on their home background. From the teacher questionnaire, teachers' personal and professional information was used. The variables impacting on instructional efficiency as taken from the teacher and learner questionnaires were teacher in-service training, classroom teaching resources, teacher characteristics, learner characteristics, teacher allocated time, and learner engaged time.

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The analysis of data was undertaken in two stages, the first of which was the descriptive and correlational analysis. The aim of descriptive analysis was to present and describe the experiences of teacher and learner participants. Correlational analysis was aimed at describing the type and strength of associations between variables associated with instructional strategies and learner scores. The second part of the analysis constituted the inferential statistical analysis applying PCA and Hierarchical Multiple Regressions. PCA was carried out to select, from a pool of variables, those that could further be used in the process of building Hierarchical Multiple Regression analysis, aimed at developing sets of variables that could be used to predict learner achievement in Grade 6 Mathematics for the SACMEQ III project. The two-stage analysis was of Mpumalanga data in comparison to Gauteng and South African national data. The reason for the comparison with Gauteng was that the two provinces are neighbouring provinces and share some characteristics and differ in others. Both have many languages while they differ in the level of economic development. Mpumalanga is mainly rural whereas Gauteng is mainly urban, but both have more than four languages. The main languages in Mpumalanga are Swazi, Zulu, and Tsonga while Gauteng has Zulu, Sotho, English, and Afrikaans as the main languages (South African government, 2016). Although 64% of the South African population live in urban areas (The World Bank, 2016), the country has large number of rural areas which give it some similarity with Mpumalanga which is largely rural.

6.3 SUMMARY OF THE RESEARCH FINDINGS

The purpose of this study was to find out the effect of instructional efficiency on Grade 6 learners Mathematics achievement in Mpumalanga in SACMEQ III. To achieve it, the following main research question was used: What is the effect of instructional efficiency on Grade 6 learners' mathematical achievement in Mpumalanga in SACMEQ III? The results of the study are presented to answer the five secondary questions, leading to answers of the main research question. The descriptive analysis is used to answer sub-questions 1 to 4 (6.3.1 to 6.3.4), whilst the results of the inferential statistical analysis are used to answer sub-question 5 (6.3.5).

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6.3.1 Sub-question 1

How did Mpumalanga learners perform in Mathematics in SACMEQ III and how did it compare to Gauteng and South Africa?

The overall result of Mpumalanga was a mean Mathematics score of 476.1 (SE= 8.9), which was 23.9 points below the SACMEQ mean score of 500 for all 15 countries. In general, most Mpumalanga learners (79%) operated at the lowest three levels (pre-numeracy, mergent and beginning numeracy) out of eight, revealing that at Grade 6 they were not operating at and were far below the appropriate expected grade level in Mathematics (see section 4.2). Fewer than 1% of the learners achieved at two highest competency levels, which are the *concrete problem solving* and *abstract problem solving level* which means they could solve multi step mathematical problems and identify and solve unstated problems embedded within other information. On the contrary, Gauteng learners achieved the mean score of 545.0 (SE=11.99), which was 45.0 points higher than the SACMEQ mean score. About 45% of learners achieved the basic numeracy skill or lower and this is 34% and 24% less than in Mpumalanga and nationally. This means that the majority (55%) of Gauteng learners could operate at the beginner numeracy level or higher. Nationally, the learners' mean score was 494.8 (3.81), which was 18.7 points higher than of Mpumalanga. Similar to Mpumalanga, the majority of learners (69%) achieved at basic numeracy level or lower and fewer than 1% of learners could solve abstract mathematical problems.

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6.3.2 Sub-question 2

What is the relationship between characteristics of learners and their achievement in Mathematics?

- *Possessions at learner home*

In Mpumalanga, learner *home possessions* associated with convenience such as computers, Internet, cameras, washing machines and vacuum cleaners were owned by a significantly lower percentage (< 30%) of households than in Gauteng, where (43%) of learner homes had them. These items showed positive relationships with mathematical achievement, however the relationships were weak (*r* ≤ *0.27*), which means that although learners from homes in which these items were available were likely to perform better in Mathematics, yet the relationship between such items and performance was weak. In Gauteng, *home possessions* such as computers, Internet, washing machines, vacuum cleaners and cameras were owned by a moderate percentage of learners' families (43%), which was more than 10% higher than in Mpumalanga. This could be because Gauteng is more economically advanced than Mpumalanga. Similar to the situation in Mpumalanga, these possessions had positive but weak relationships with learner performance. On the other hand, in Gauteng and the South Africa overall the relationships between computers, washing machines and vacuum cleaners and learner performance were moderate and positive (≥ 0.42).

In Mpumalanga and Gauteng, newspaper access showed a positive association with learner scores. While the relationships were generally weak in all three groups, in Gauteng they were much weaker *(r = 0.09)* than in Mpumalanga (*r = 0.21).* This might be an indication of the existence of differences in literacy opportunities and access to information in the two provinces. In a rural area such as Mpumalanga, a household that is inclined to engaging in literacy activities might have relied on newspapers, while in Gauteng it might have had an option of Internet due to the ease of connectivity in urban areas. *Audio and communication possessions*, *media and study possessions* and *borehole and bicycle possessions* (see Chapter 5) had very weak relationships with mathematical achievement in Mpumalanga, therefore they were not analysed further.

- *Parental educational levels*

In general, Mpumalanga learners had parents who were less well-educated than their counterparts in Gauteng and across South Africa. While *all secondary* school level was the modal educational level for parents in all the three groups, in Mpumalanga this level was achieved by an average of 15% of parents as opposed to 20% and 16% respectively in Gauteng and South Africa overall. In Mpumalanga, learner parental educational level showed positive but weak association with learner achievement (*r* = *0.23*) (see section 4.5). This suggests that education of parents often had minimal effect on learner performance, perhaps due to that large percentage of parents with low educational levels, therefore resulting in low variation in the data. In Gauteng moderate positive relationships existed between learner score and parental educational level (see section 4.4), suggesting that a learner with educated parents had reasonable chance of performing better in Mathematics. This is understandable since educated parents can give both academic assistance and motivation to their children (Ademola & Olajumoke, 2009). South Africa was similar to Gauteng where moderate positive relationship existed between parental educational level and mathematical performance.

- *Type of home dwelling*

Learners in Mpumalanga lived in less expensive made houses than in Gauteng and South Africa and learners in Gauteng tended to have houses made out of the most expensive materials (see section 4.3). The house materials were positively related to achievement with the strongest relationships being found in Gauteng (see section 4.4). The relationship between wall and floor materials used for the construction of learners' home and mathematics achievement were positive but rather week in Mpumalanga *(r = 0.24)* and nationally. In Gauteng, these building materials' association with mathematical performance were moderate and positive (*0.35) (*see section 4.4). A positive relationship between home dwelling and mathematical achievement implies that learners who live in less expensive houses tend to achieve low scores in Mathematics.

With Mpumalanga being a predominantly rural province, the likelihood was that the differences in type of dwellings could have been limited. On the other hand, Gauteng, being an urban province with the largest GDP in South Africa, could have had homes constructed of many different kinds of material. Therefore, the variation in types of dwelling could have indicated differences in economic status. People of higher economic status can afford comfortable homes which can offer learners comfortable learning environments and facilities such as computers and Internet which are important for academic activities.

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- *English Language spoken at home*

Language can often have an influence on learning and performance (Howie, 2003). In Mpumalanga, the majority (71%) of learners spoke English irregularly while 19% never *spoke English at home.* Moreover, only about 2% of learners were regular speakers of *English at home*. In contrast, Gauteng had the lowest percentage (about 10%) of learners who never *spoke English at home* and the highest percentage (about 12%) of learners who regularly spoke the language at home. The association between English language and performance was positive, which suggests that learners who never spoke English were likely to perform worse in mathematics than their counterparts who did speak the language regularly. In Mpumalanga the relationship was weak *(r = 0.18),* while in Gauteng it was moderate (*r = 0.39*) and weak in South Africa overall (*r = 0.34*). In Mpumalanga and nationally the weak relationships might have been an indication that few learners were speakers of the English language at home, so the language made negligible difference to their performance (see section 4.4).

6.3.3 Sub-question 3

What is the relationship between time on task and learner achievement?

Time on task was represented by the *number of periods per week, minutes per lesson* and *homework given* to learners. The time allocated for instruction varied among the three groups where Mpumalanga had the the lowest number of periods per week (25) compared to Gauteng (38) and South Africa overall (35). Furthermore, in Mpumalanga about 67% of learners were given homework on most days of the week while about 1% was never given homework. About 60% and 56% of leaners in Gauteng and South Africa respectively received homework on most days of the week. However, about 4% of learners nationally and in Gauteng were never given homework. There was no relationship between time on task and learner achievement in Mpumalanga. This finding was unexpected (see section 4.4) as it suggests that the length of period, number of periods per week or homework given to learners (as currently measured by SACMEQ) had no real impact on how learners performed in this group. In Gauteng the relationships between *minutes per*

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lesson (*r = 0.43*) and *homework* given to learners (*r = 0.37*) were moderate. However, since the primary focus of the study was Mpumalanga, those variables that had no associations with mathematical performance in Mpumalanga were not analysed further than the correlational analysis. As a result, *time on task* variables (*minute per lesson and homework given)* were not analysed further in this study.

6.3.4 Sub-question 4

What is the relationship between quality of instruction and learner achievement?

Teachers in Mpumalanga were younger, less experienced and more than half of them were male compared to Gauteng and nationally where more teachers were female and better qualified (see section 4.3). Having younger teachers could have been an advantage to Mpumalanga learners as these teachers would have received better training than their older counterparts. The majority of teachers (62%) were male, perhaps because Mpumalanga, being largely rural, had a limited number of industries and therefore social services such as education and health tended to be the main employers of labour. Academically, teachers in Mpumalanga were less well-qualified, more than one-third (38%) of teachers had a primary school academic qualification, which was the common one. In contrast, the common academic qualification in Gauteng was a degree (see section 4.3). There were no relationships between Mpumalanga (and South Africa) Mathematics learner score and the variables explained above (*teacher age, sex, and years of teaching and academic qualifications*). In Gauteng, a weak but positive relationship existed between mathematical achievement and *teacher sex* (*r = 0.26) (*see section 4.3). However, since further analysis was guided by Mpumalanga results, *teacher sex* and all the other variables mentioned above were not analysed further than the correlational analysis (see Chapter 3).

In regard to professional training, more than two-thirds (68%) of Mpumalanga teachers had three years of professional training, such as Primary Teachers Diploma, studied for in teacher training colleges in the pre-1994 period. On the contrary, majority of teachers in Gauteng (69%) and nationally (50%) possessed three-year plus professional qualifications. Mpumalanga had no university but

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several colleges of education, hence it was not surprising to see that the majority of its teachers had these undergraduate qualifications. Furthermore, merely 21% of teachers had three-year plus professional qualifications, that is, university degrees such as a Bachelor of Education (BEd) or 4 years teachers diplomas. With Mpumalanga having had no university, students who wished to enrol for university degrees had to travel to other provinces such as Gauteng. It was therefore, not unexpected for Mpumalanga to have had low percentage of teachers with teaching degrees. Unlike in Gauteng and nationally where teacher professional training had no association with mathematics performance, in Mpumalanga the relationship was weak but negative *(r = -0.20)*. This implies that learners who were taught by teachers whose courses were longer often performed worse than those whose teachers were less qualified. Initially this result was puzzling until one scrutises the way that the question options were presented. Higher qualifications are synonymous with longer periods of time for study which are expected to equip a teacher with better skill in handling the subject. However, considering that SACMEQ used number of years that a teacher spent training for a particular qualification (and not the level of training) as a measure of whether a teacher is more or less qualified, it is not surprising that the relationship between professional qualification and learner performance was negative. In South Africa, teacher education qualifications varied hugely and were racially based leading to a wide variation of possible courses up to 1996 (see chapter 1 and 4). For instance, some postgraduate teacher qualifications such as Post Graduate Certificate in Education take one year of study, but they are higher in standard as they are postgraduate level. A teacher requires a degree to enrol for such qualifications. Therefore, a teacher with a three-year qualification such as Primary Teachers' Diploma from a college of education, which is an undergraduate qualification, is less qualified than the one with PGCE. This means using number of years to measure how qualified a teacher is may be problematic, hence the negative relationship between learner score and teacher professional qualification.

Resources used in the classroom are of importance in making the instructional process efficient. About 98% of Mpumalanga classrooms had a writing board and chalk, however only 34% had classroom-based libraries (see section 4.3). Similarly, resources such as cupboards and bookshelves were available in only ≤ 27% of

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classrooms. In Gauteng and nationally, writing board and chalk were available in about 80% and 98% of classrooms respectively. While these resources are core to classroom instruction, their contribution is affected by the availability of other resources such as books and computers. Chalk and board are traditional teaching resources and are often needed for summarising what has been learned using other resources. Negative relationship were shown to exist between chalk and board and mathematical score in Mpumalanga. It might have been that in general, Mpumalanga schools did not possess any other resources, therefore there was very little to summarise. By contrast, it might have been that the emphasis had shifted to other forms of teaching resources such as smart boards and overhead projectors. The relationships between chalk and board and mathematical achievement was weak and negative ($r = -0.29$) in Mpumalanga, while in Gauteng writing board had a positive association with mathematical achievement (no relationship existed between performance and chalk). On the other hand, a classroom library had a positive albeit weak relationship with learner achievement ($r = 0.25$) in Mpumalanga and nationally ($r = 0.21$) (see section 4.4), which suggests that learners who learn in classrooms with libraries tend to perform better. This is not surprising as classroom libraries are often an an indication of the availability of other resources such as computers and internet which may contribute positively to performance.

6.3.5 Sub-question 5

What is the quality of instruction in Mpumalanga in relation to Gauteng and the overall South Africa and how does it influence Mathematics achievement?

Hierarchical Multiple Regression analysis was used to largely address this question and was designed largely based upon the conceptual framework presented in Chapter 2. Regression models for Mpumalanga, Gauteng and South Africa were analysed. For each group, the regression analysis took place in two stages. The The predictors in the first stage were *convenience possessions, electrical possessions, transportation possessions, wall material, floor material, English spoken at learner home, Learners' mother educational level and learners' fathers' educational level* (level 1). Stage 2 comprised level 1 predictors plus *classroom furniture and library, teacher professional qualifications and teaching aids* (level 2).

The models were refined until only predictors which were making significant contributions to the models were retained.

The predictors of performance in Mpumalanga in comparison with Gauteng and South Africa overall are described below, in accordance with the elements of the conceptual framework.

- *Level 1*

In Mpumalanga, learners from homes with more *convenience possessions* and made from more expensieve materials tended to do better compared to learners from poorer homes. This was indicated by positive contributions to mathematical score by *convenience possessions* (0.06 SE=0.07) and *wall material* (0.56 SE= 0.11). However*, transportation possessions* such as donkey cart and motorcycle had negative relationships with mathematical performance, which implies that learners from homes with these possessions often performed poorly in Mathematics. These possessions reduced learner scores by 1.57 (SE=0.24) points. Learner parental educational level had no significant contribution to the model as such were removed from Mpumalanga model.

In Gauteng parental education and English in the home were significant positive contibutors to explaining mathematics performance. *Convenience possessions* added 0.75 (SE=0.08) points while *electrical possessions* increased learner score by 0.57 (SE=0.18) points. Similar to Mpumalanga, *transportation possessions* had a negative association with learner performance, decreasing mathematics score by 1.10 (SE=0.30) points. Unlike in Mpumalanga, parents' educational level made significant contributions to learner performance. *Mother's educational level* added 0.27 (SE=0.08) points while *father's educational level* added 0.71(SE=0.06) points to the learner score. Moreover, English language spoken at home had a strong impact on performance, adding 1.8 (SE=0.24) points to achievement.

In South Africa overall, *convenience possessions* and *floor materials* for leaner home contributed positively to learner score. On the other hand, *wall material* for learner and *transportation possessions* had negative relationships with learner

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score. They reduced learner achievement by 0.47 (SE=0.04) points and 1.25 (SE= 0.10) points respectively. Both mother's and father's educational levels contributed positively to the learner score. Similar to the situation in Gauteng, the English language made a strong contribution to learner performance, adding 1.30 (SE= 0.08) points to learner score.

- *Level 2*

When the level 2 variables are added to the model in order to explain mathematics achievement, interesting occurances take place. The level 2 variables add very little explanation except in Mpumalanga. Generally, the contribution of the variables on level 1 changes when level 2 variable are included (see section 5.3). This means once the SES, language and parental educational level variables are added, the classroom level variables do not contribute much to explaining mathematical achievement in Grade 6.

In Mpumalanga, *classroom furniture and library* was a positive predictor of learner achievement, increasing the learner score by 1.00 (SE=0.18) whereas, *teacher professional qualifications* and *teaching aids* such as writing board had negative associations with mathematical performance. This means their availability in the classroom often increased the likelihood of a learner having a low performance. *Teacher professional qualifications* reduced the learner score by 0.92 (SE=0.24) while *teaching aids* reduced performance by 1.14 (SE=0.19). On the other hand, in Gauteng *classroom furniture and library* was the only predictor of learner performance related to teaching strategies. It had a positive relationship with learner achievement, contributing 0.70 (SE=0.20) to learner score. In the overall South African classrooms, *furniture and library* was a strong positive predictor of performance, making a positive contribution of 0. 91 (SE=0.07) points to learner score.

Unlike in Mpumalanga, nationally, *teacher professional qualification* was a positive predictor of mathematical achievement, which means that learners who were taught by highly qualified teachers were likely to perform well in Mathematics. The predictor added 0.25 (SE=0.08) points to learner results. Similar to the situation in

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Mpumalanga, *teaching aids* showed a negative relationship with learner achievement. Its contribution to the learner achievement was a reduction of score by 0.30 (SE=0.05) points.

The instruction - related variables for Mathematics in this study were not found to be generally strong predictors of mathematics achievement. In fact in Mpumalanga, *classroom resources* and teacher *professional qualification* were weak predictors, although they added the greatest amount of explanatory power compared to the Gauteng and SA models. Ultimately, factors related to the learners' background and SES most especially, explained more of the differences in achievement than the classroom factors.

6.4 REFLECTION ON METHODOLOGY

This study is a secondary analysis of the SACMEQ III data collected in 2007, about nine years prior to this study and as such some factors have since changed. For instance, teacher professional training in Mpumalanga has changed. The province has a university which offers teacher professional training. Therefore, this serves as a drawback to this study. Moreover, SACMEQ projects are trend studies as such items in the questionnaire are meant to be similar to those of the preceding studies. However, the SACMEQ III project removed several items in the questionnaires addressing teaching and assessment in the classroom. These are items such as activities, goals and approaches used in Mathematics. From a policy and practice perspective obtaining insight into the classroom, this was unfortunate as no trends could be measured nor could comparisons between studies be made. The omission of these variables also limited the number and type of variables that could be analysed for this study and the data had more learner variables than instructional variables. Such a situation makes this kind of research difficult to undertake (Howie, 2002). This also served as a drawback to this study.

The study used data collected by means of self-administered questionnaires, the limitations of this method are well known (Gay, Mills & Airasian, 2009). Bearing this in mind SACMEQ used triangulation between instruments and within instruments and between items. Furthermore, reliability analyses were used in this study to

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determine the internal consistency of items used. A Cronbach's alpha value of 0.50 was the minimum for accepting that the items were measuring the same construct (see Chapter 3 and 5). Nonetheless the models built in this research depend on self-report data and therefore this limitation should be kept in mind.

Guided by the conceptual framework, variables were selected from the SACMEQ III data. The descriptive and correlational analyses of the data for the three groups were undertaken. The descriptive analysis was aimed at finding out if there were any missing data in the three groups. The aim of correlational analysis was not to find out if causal relationship existed between instructional strategies and mathematical results but to determine if any relations existed between the instructional strategies and mathematical achievement. Some of the relationships were non-significant, indicating less variation between the data. As a result, those variables with correlation coefficient of less than $r = 0.20$ were excluded from further usage in the study. Most of the correlations were also limited to a weak level with very few strong relationships found. This is a common problem with data analyses in the social sciences (Howie, 2002).

The second analysis stage involved the use of inferential statistical methods of Principal Components Analysis and Hierarchical Multiple Regression analysis. The high volume of items was a limiting factor for conducting multiple regression analysis, therefore the Principal Component Analysis was useful in reducing the volume while retaining as much of the information as possible. Variables selected from Mpumalanga data were used for PCA (see Chapter 3 and 5) because Mpumalanga is the primary focus of the study. Only those components with a reliability coefficient of $r = 0.50$ were used in the Hierarchical Multiple Regression model building, to ensure that the variables forming a particular component addressed the same underlying issue.

The hierarchical regression analyses were of the data, some of which was first recoded to make it meaningful. Hierarchical Multiple Regression analyses were then conducted for Mpumalanga, Gauteng and South Africa overall using factors formed in PCA. Additionally, guided by the Mpumalanga results, variables with correlation coefficient of a minimum of $r = 0.20$ were included in the regression

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models. The same variables were entered for the regression analysis for all the groups. This was to see how factors affecting Mpumalanga affect other two groups. The aim of the analysis was to find variables that could be used to predict the learner mathematical achievement in Mpumalanga in comparison with Gauteng and South Africa overall. The reason for the comparison was that Mpumalanga shared some features with both Gauteng and the nation (see Chapter 4 for more information).

6.5 REFLECTION ON THE CONCEPTUAL FRAMEWORK

The study's conceptual framework was based on Slavin's (1995) effective instruction model (QAIT model), adapted to align with the SACMEQ III data which was used in this study. The QAIT model has two main components, namely, student inputs and alterable variables. The former are aptitude and motivation, which are factors that the learner brings into the classroom, the latter are quality of instruction, appropriate level of instruction, incentive to learn, and time. The alterable variables are the responsibility of the teacher and as such this study was based on them (see Chapter 2).

The adaptation of the QAIT model gave way to the instructional efficiency model which consists of three elements, namely, characteristics of learners; characteristics of teachers and instructional strategies; and in-school and out-of-school time. The element of incentive to learn was not adapted due to the lack of the SACMEQ data to address it. However, this element addresses an important part of the process of instruction which pertains to interest. Learning can be increasingly successful if learners are interested and encouraged to participate actively (Slavin, 1995). I think the SACMEQ should consider addressing the *incentive to learn* variable in their future projects.

The element of appropriate level of instruction in the QAIT model speaks to the factors such as ability grouping. However, there was no data to address it as explained in the original model; therefore the data concerning characteristics of learners were used. Learner characteristics explain the socio-economic background which could affect the level at which the teacher pitches the instruction. A large

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amount of data in the SACMEQ projects relates to socio-economic status, therefore it seemed appropriate to include these variables for their influence on the learning and teaching process.

The element of quality of instruction in the QAIT model addresses factors such as instructional approaches and assessment strategies. In the adapted model, quality of instruction speaks to the same factors as well as classroom resources, in-service training and teacher characteristics. While SACMEQ had to address teaching and assessment factors in their earlier SACMEQ I and II projects, the same variables have been removed in project III and and it was not clear why this was the case but it limited the possibilities for analysing the adapted Slavin model. Therefore, variety of teaching techniques was not addressed in this study. I think SACMEQ should reinstate them in its future projects, because teaching forms an integral part of the instructional process. Additionally, measuring the level at which learners perform and the level at which teachers conduct instructional activities should be addressed.

6.6 CONCLUSIONS

There are five main conclusion drawn from this study and are presented below.

Conclusion 1: English language proficiency and exposure has an effect on learner mathematics achievement in Gauteng and South Africa

The results of this study confirm that English spoken at a learner home has an impact on mathematics achievement. This was found to be the case in South Africa overall and in Gauteng. The effect of the English language on performance in Mpumalanga was found to be non-significant (see section 5.3). van Staden (2010) explains that the absence of statistical significance does not imply the absence of educational significance. Although English was not a statistically significant predictor in Mpumalanga, where few learners spoke the language frequently, its impact on achievement could be substantial as English is the LoLT for the majority of learners, which is often the case with learners who are not native speakers of English, most of whom live in rural areas. In TIMSS 1999, learners from rural provinces such as Mpumalanga performed poorly in comparison to their urban

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counterparts (Howie, 2003). Native speakers of English often lived in urban areas and in rural areas the majority of learners have fewer opportunities to speak the language.

In contrast, in Gauteng and nationally English was a strong predictor of performance as it improved learner score by 1.87 (*SE=0.24)* and 1.30 (*SE= 0.08*) points respectively. This shows that the learner's ability to speak the English language may influence achievement, which is understandable because Gauteng as an urban province may give people greater access to situations that allow them to use the language. Some can continue using the language at their homes. Moreover, in Gauteng only about 10% as opposed to about 19% of learners in Mpumalanga never spoke English at home. Exposure to situations that require the use of English could refine learners' abilities to use the language effectively in academic situations. This is in line with Passos' (2009) findings that the more learners speak the language of instruction at home the better their chances of high performance in Mathematics, because the everyday English spoken at home can serve as a foundation for jargon, and while Mathematics instruction takes place in English the subject has its own language, one more complex than everyday English.

Specialised mathematics words such as "vertical", "horizontal" and "subtract" are not part of everyday English, therefore, non-native speakers have first to master the everyday English, and this can be an extra challenge on their part (Mosqueda, 2010). This concurs with Adu and Olaoye's (2015) explanation that Mathematics has its own vocabulary, syntax and semantics and discourse properties. The vocabulary of Mathematics includes specialised words such as "denominator" and "coefficient", and everyday words such as "table" and "column". Consequently, Mathematics is not devoid of language but it is language-based, affirming that English language skill precedes mathematics skill, for which the language of learning and teaching is English. A challenge for non-native English speakers is often that learning the language of instruction simultaneously with Mathematics content complicates the learning process (Denfield, Nistor & Baltes, 2014).

Conclusion 2: Learners with educated parents have a higher likelihood of achieving a better performance in mathematics.

The results of Hierarchical Regression analysis indicate that parental level of education can predict influence learner mathematical performance. The extent of the effect differs between Mpumalanga, Gauteng and South Africa overall. In Mpumalanga, parents' education was a non-significant predictor of performance, which means that parents' education made a negligible difference to learner performance. Generally, due to lower education level, parents in rural areas such as Mpumalanga tend to have limited participation in their children' education, which contributes to lower learner performance in Mathematics (Graham & Provost, 2012). On the other hand, in Gauteng both the mother's and father's education levels were significant predictors of the learner score. The situation was similar in South Africa overall, for which the mother's education improved performance by 0.27 points while the father's added a meagre 0.20 points. Azhar, Nadeem, Naz, Perveen and Sameen, (2013) assert that the mother's education has more influence on the child's academic performance than that of the father, as the maternal bond is stronger so her views are often more easily adopted by the child. On the other hand, the education of the father is also important as often the SES of the family rests on them.

The results show that the higher the parental level of education the greater the chances of learner performing well in mathematics. This upholds the view that children of educated parents often perform well in school because these parents serve as role models for their children (Jabor, Kungu, Machtmes, Buntat & Nordin, 2011). Educated parents can help their children in many ways, such as providing necessary support and facilities to enhance the learning process. They can also provide academic support that can improve their children's level of knowledge (Azhar et al., 2013). According to Alokan, Osakinle and Onijingin (2013), educated parents can provide study facilities such as home libraries with materials that include novels, encyclopaedias and tapes. These resources can enhance the child's intellect. They further point out that learners whose parents have reached tertiary educational level often performed better than those whose parents had only basic schooling. This confirms Visser, Juan and Feza's (2015) findings that learners

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whose parents had an educational qualification higher than Grade 12 tended to perform better in Mathematics than learners with parents with Grade 12 or lower qualification. Moreover, educated parents tend to provide their children with early independence training by insisting on self-reliance in decision-making processes. Educated parents often provide their children with achievement training by setting high achievement goals, thus motivating them to work harder in academic activities.

Conclusion 3: Teacher professional training has an effect on mathematical performance in Mpumalanga and South Africa

Teacher professional training was a negative predictor of performance in Mpumalanga (see section 5.3.2), upholding Passos's (2009) findings in her SACMEQ II study that while teacher professional training was a non-predictor of learner achievement in other SACMEQ countries it was a negative predictor in South Africa. In Mpumalanga, teacher professional training decreased learner score by 0.92 (SE=0.24) points. Teacher professional qualification as a negative predictor of learner achievement contradicts the traditional view that professional training makes teachers efficient and effective (Passos, 2009), and learners taught by teachers with high professional qualifications, such as degrees, often perform better than those taught by teachers with lower qualifications, such as diplomas and certificates (Abe, 2014). In this study, this anomaly appeared to have been partly explained by the measurement used by SACMEQ that appears to have confounded the teacher professional qualification variable as discussed in section 4.3.2.1. However, in South Africa overall, teacher professional qualifications were positive predictors of learner achievement, in line with the findings of Akinsolu's (2010) study that teacher professional training correlated strongly with academic performance. This means that the higher the teacher qualifications the better the learners were likely to perform. Learner score increased by 0.25 (SE=0.08) points as a result of teacher professional training.

The quality of teacher training could have been the reason professional qualifications seemed not to bring about improvement in achievement (Passos, 2009). In Mpumalanga, about 68% of learners' teachers possessed three-year teaching qualifications, notably diplomas such as Secondary Teachers' Diploma

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and Primary Teachers' Diploma. These were part of the Bantu Education system which was commonly regarded as of inferior quality. All of these teachers were trained prior to 1994, as evidenced by their average age of 41 years. Therefore, their three-year training seemed to equip them with little of the real knowledge and skills needed for handling the Mathematics subject. Moreover, as already explained in section 4.4.2.1, the 1 year postgraduate diplomas were mixed up with one year certificates and diplomas, and this could have contributed to the negative relationship between learner score and professional qualifications. Another issue might be that these teachers were professionally trained but not in Mathematics teaching (Abe, 2014). The SACMEQ data do not collect data on subject specialisation, therefore it is difficult to know what percentage of the teachers had been professionally trained in Mathematics.

Conclusion 4: Socioeconomic status is a substantial predictor of learner achievement

Variables related to SES appear to predict mathematics achievement and explained most of the variance in the mathematics achievement. *Possessions at learner home* and the *type of dwelling* for learners as measures of social and economic standing of learners affected the performance of learners. Although educational level is also part of SES it is excluded under this discussion since it is described under conclusion 4. *Parental educational level* is described separately because it is of high importance to learner achievement. Possessions owned in a learner's home are predictors of learner performance in Mathematics. In Mpumalanga and nationally, only *convenience possessions* and t*ransportation possessions* were predictors. *Convenience possessions* such as computers and Internet positively influenced performance, while *transportation possessions* such as horse cart and tractors were negative predictors of learner achievement. *Electrical possession*s were non-predictor of performance, which implies that whether available or not they did not impact in any way on the performance of learners in Mathematics in Mpumalanga or nationally.

Moreover, *electrical possessions'* impact on performance is non-significant. This is surprising since electricity as one of those possessions is of great importance to the

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process of learning both in and out of school. However, with Mpumalanga being a predominantly rural province there may have been many areas which had no access to electricity in 2007 when the SACMEQ III data was collected. The effect of lack of electricity on education includes the inability of the learner to engage in academic work at night. This affects academic activities such as homework and studying (Nelson Mandela Foundation, 2005).

The ownership of possessions such as tractors and horse cart resulted in declined learner performance. Perhaps learners whose families owned tractors received less assistance with their out-of-school studies as their parents were engaged in farming activities, which could be exhausting. On the positive side, the ownership of *convenience possessions* such as computers, washing machines, Internet and cameras often increased performance of learners. Computers and Internet can allow learners to engage in academic research, while washing machines and vacuum cleaners can shorten the time spent on domestic chores. Therefore, learners' parents could have been afforded sufficient time for assisting their children's academic activities. Items such as computers and internet are often associated with higher SES. Mpumalanga, is a predominantly rural province with a poverty level of about 52% (Statistics South Africa, 2014) so it was understandable that most learners' families did not have such possessions.

While it is evident that facilities such as computers and internet are valuable, their influence on mathematical performance depends on how they are used. Fairlie & Robinson (2013) point out that the ownership of the facilities does not guarantee an improvement in learner achievement. This is because learners can spend more time playing games and social networking rather than doing academic activities and seldom educational softwares are installed on home computers. However, where parents provide guidance to their children computers and internet can help to improve the time learners spend doing academic activities. for example parents can stipulate rules on how the computer can be used (Malamud & Pop-Eleches, 2010).

The physical type of residence for learners had an association with mathematical achievement. In Mpumalanga, the type of *wall material* used in the construction of learner home was a substantial positive predictor of achievement. This implies that learners whose residences were made of expensive building materials were inclined to achieve better scores in Mathematics. *Wall material* added 0.56 (p = 0.000) points to learner achievement in Mpumalanga. The positive link between the type of home and achievement does not come as a surprise because in general, expensive homes are furnished with facilities that can provide comfort, therefore facilities suitable for educational purposes, such as study area, are often found in such homes. This can help to motivate the learner to engage in their studies after school hours (Moula, 2010). The home is the first place for learning for children, therefore the quality of home environment is important for learner achievement. A home with facilities such as library can have a positive influence on academic achievement. A home library with materials such as books, audio and visual tapes can boost the intellectual ability of a child (Alokan, Osakinle &Onijingin, 2013).

Conclusion 5: Classroom resources have an influence on performance in mathematics

Classroom resources such as bookshelves and classroom library are positive predictors of performance in all the three groups (see section 5.3.2. In Mpumalanga, the unstandardised coefficient of 1.00 (S=0.18), which indicates that the greater the availability of *classroom furniture and library* the greater the likelihood of improved learner performance. Resources such as libraries are regarded as potent determinants of whether learners succeed in their learning (Owoeye & Yara, 2011). However, with a library having been available in only 34% of classrooms in Mpumalanga, the majority of learners had no opportunity to obtain or engage with various learning materials. on the contrary, negative relationships were shown to exist between *teaching aids* such as chalkboard and chalk and performance in Mathematics. While at face value it is uncomprehensible to have such fundamental resources associating negatively with mathematical achievement, it might have been that many classrooms did not have any other resources that were needed for making learning successful or the other resources were employed wrongly. Therefore, the usage of these fundamental resources may have been ineffective.

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6.7 RECOMMENDATIONS

Taking into consideration the conclusions reached for the study, this section makes recommendations for practice, policy, and further research.

6.7.1 Recommendation for practice

Classroom resources such as books and other reading materials are important for the instructional process, therefore there is a need for a library in each classroom to cater for learners' and teachers' needs for instructional materials. Learners from homes with less reading material, such as newspaper and magazines, can benefit greatly since the library could be the only source of reading resources. The classroom library should contain a variety of mathematics books and games, such as puzzles.

Classroom libraries are indirectly connected to the issue of the learners' ability to speak English. One of the ways in which language can be learned is through reading so the availability of books in the classroom library can enable learners to improve their understanding of English. While one of the two LoLTs in Grade 6 is English, SACMEQ III findings indicated that Mpumalanga learners had performed lower than the mean of 500 in English reading. Their mean score of 473.6 (SE = 11.13) indicates that their English language skill was not up to the required standard (Moloi & Chetty, 2010). In many schools in which learners are non-native speakers of English, teachers often use code switching when delivering lessons (Setati, 2008). While this can help learners to understand the content, it can be detrimental if overused. The disadvantage of excessive code switching can be over-reliance on the practice in such a way that learners do not concentrate on learning the content in English. Therefore, teachers should be aware of the pitfalls and advantages of code switching and use it only when necessary.

The Education authorities should put in place measures that can support teachers who teach learners who are non-native speakers of English. This is important since the majority of learners in Mpumalanga and South Africa are taught in a language which is not their mother tongue (Zimmerman, 2010). The Education authorities

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should ensure continuous monitoring of how teachers use the English language. Moreover, teachers should be supported by subject advisors whose duties include monitoring and supporting teaching personnel.

Low SES can have a negative impact on learning outcomes; therefore the Education Authorities can limit this impact by supplying schools with the necessary learning resources (learning and human). Learners should be supplied with adequately furnished learning spaces, so enhancing their feeling about their classroom environment and in turn increasing their involvement in learning activities (Passos, 2009). Schools can offset the effects of low parental education by engaging in a practice whereby learners are informally adopted by teachers. This can grant learners with parents who are poorly educated an opportunity to have an educated adult as a mentor. Teachers can guide and encourage these learners as their own on many issues, including but not restricted to academic matters. The learners need not be in the teacher's class to be mentored. Such interactions can give confidence to learners and make them want to emulate their mentors. The education authorities can endorse the practice by awarding points to the participating teachers. The accumulated points can be converted into a scholarship for further study by the teacher or a tax rebate to be claimed from the receiver of revenue. In the long run, the little tax forfeited by the South African Revenue Services can result in a large number of educated people who can help to uplift the economy of the country.

The effects of teacher training being a negative predictor can be related to the type of candidate who enters the teaching profession. Primary teaching is often not seen as an attractive profession; therefore bright candidates are taken by other professions (Passos, 2009). While strategies such as Funza Lushaka bursary programme have been used, which involve funding eligible students for qualification in Education, the trainee teachers can be exposed to findings of large scale research such SACMEQ, TIMSS and PIRLS to familiarise themselves with the conditions of teaching and learning in the classroom.

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6.7.2 Recommendations for policy

The impact of classroom resources on teaching and learning to a certain degree depends on how they are managed. The provision of classroom resources to poor schools can bring about greater improvement in the quality of learning and teaching if policy directives on effective management, utilisation and maintenance of the resources at schools are available (Zimmerman, 2010). Provision of classroom libraries can be of help in providing learners with books and games important for Mathematics. Policy on classroom library usage can include how learners should handle and borrow books. While games can stimulate learners' thinking there is a need for these games to be played in a managed environment. The policy should include the frequency with which games can be played and the length of time that learners can spend playing such games.

Supplying learners with adequate learning spaces can limit the effects of low SES on learners from poor homes (Passos, 2009), therefore school building maintenance policy is important to prolong the life of the facilities. Sometimes newly erected school buildings become dilapidated prematurely due to lack of clear guidelines of whether it is the school governing body or the Department of Education who should carry out maintenance.

In order to encourage the practice of teacher mentoring learners with less educated parents, a policy needs to be developed. At school level, this can stipulate the number of learners per teacher and how often mentors should meet with the learners they are mentoring. At the Department of Education level the authorities can stipulate how the points given to teachers are to be calculated and implemented.

6.7.3 Recommendations for further research

This sub-section contains recommendations for further research that arise from but are not restricted to the main conclusions:

- As already mentioned (see section 6.5), SACMEQ II project had data that addressed the teaching approaches, goals and activities, which have since been removed in SACMEQ III study. It is recommended that SACMEQ reinstate these variables in its future projects, because teaching and assessment form an integral part of the instructional process. Moreover, a further study should be conducted using the instructional efficiency model which is the conceptual framework for this study (see Chapter 2) to analyse the SACMEQ II data (which include the removed instructional variables) to see the findings that will emerge.
- The regression analysis indicated that only 52% of learner performance in Mpumalanga, 66% in Gauteng and 59% in South Africa overall can be explained by the predictors. This means there are other factors that contributed to poor mathematical performance of learners, therefore, more research is needed to find out what these other factors are and what contributions do they make to low mathematical achievement.
- Regarding the low level of learner achievement, a further study is needed to find out the attitude of Grade 6 learners towards Mathematics and the quality of instructions that they receive from their teachers.
- In line with the finding that resources such as chalk and writing board are negative predictors of learner performance, a further study should focus on finding out the kind of resources available in an average Mathematics classroom and how such resources are utilised.
- Concerning teacher training being a negative predictor of learner performance, a further study should focus on what instructional strategies teachers use and how effectively such strategies are being carried out.
- Regarding the English language being a predictor of achievement, a further study should focus on how schools of non-native speakers of English can encourage the usage of the language.
- Regarding Time on Task, a further research study should focus on why Mpumalanga, Gauteng and South Africa overall, had differences in allocated time for formal intruction while they followed the same curriculum, which was RNCS in 2007.

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6.8 CONCLUSION

The findings of this study have shown that Mpumalanga Grade 6 learners performed poorly in comparison to learners in Gauteng. Inequality between the two provinces seems to have had a significant influence on the learner outcomes. Low achievement in Mpumalanga, which is predominantly rural, was linked to factors such as less well qualified teachers, low educational level of parents, low proficiency and exposure in English, and poor classroom resources. A further surprise element was the lack of relationship between mathematical achievement and allocated teaching time. Neither number of periods per week nor length of mathematics lesson had any effect on the performance of learners in Mathematics. This raises many questions than answers. In future, schools and education authorities can contribute to the improvement in the situation in Mpumalanga by formulation and implementation of better school and educational policies.

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