

Focus on Four

REPORT ON AN INVESTIGATION INTO
GRADE 4 MATHEMATICS TEACHING
AND LEARNING

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LIST OF ACRONYMS & ABBREVIATIONS

DANIDA	The Danish International Development Agency
DIET	Department of Education and Training (prior to 1994)
DoE	Department of Education
HoR	House of Representatives (prior to 1994)
IEA	International Association for the Evaluation of Educational Achievement
Inset	In-service Teacher Education
JET	Joint Education Trust
MEP	Maths Education Project
PEI	President's Education Initiative
POLP	Primary Open Learning Pathways
Pre-set	Pre-service Teacher Education
TIMSS	Third International Maths and Science Study
TIP	Teacher In-service Project
TLRC	Teaching and Learning Resource Centre
UCT	University of Cape Town
UWC	University of the Western Cape
WCED	Western Cape Education Department

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EXECUTIVE SUMMARY

1. Background

This report documents Focus on Four, a research study commissioned by the President's Education Initiative (PEI), through the National Department of Education (DoE).

The intention of the study is to contribute to improvements in Grade 4 Mathematics achievement through an investigation into Mathematics teaching and learning at this level. The study takes the form of a micro study of 12 teachers in the Western Cape teaching Grade 4 Mathematics in under-resourced schools. The study looks at teachers' instructional practices and learners' learning. Fieldwork and data collection for the study took place in the first term (January - March) of 1998.

2. Purpose and focus of the study

The purpose of the study was to investigate and begin to develop explicit indicators of effective Mathematics practices and pedagogical processes for Grade 4 learners. The analytical objectives of the study were to teachers' classroom practices, and growth in learner achievement and attitudes towards Mathematics. In particular, the study focused on the relationship between teachers' instructional practices and growth in learners':

- understanding and application of specific Mathematics concepts and principles;
- problem solving strategies; and
- attitude and self-concept in Mathematics.

3. The research model

The Third International Mathematics and Science Study (TIMSS), a research study sponsored by the International Association for the Evaluation of Educational Achievement (IEA) provided the research model for the study. TIMSS provided a model because it represented international consensus on curricular aims in Mathematics, and because it provided instruments tried and tested in a large scale study in 46 countries (26 at this level) for measuring the Mathematical achievement of learners. Furthermore, the model makes it possible to provide likely explanations for growth, or lack of growth in learner achievement and, consequently, to make suggestions as to how improvement might be achieved.

A full list of TIMSS documents studied during the course of the project appears in the Bibliography.

4. Research questions for the study

The research questions for Focus on Four are derived from the four research questions formulated for TIMSS. The adapted research questions for Focus on Four are:

1. What is the intended curriculum for Grade 4 Mathematics learners in 12 Grade 4 classes in the first term of 1998 (i.e. that which the teachers intend to teach)?
2. What are the variables in the social and educational contexts for learning between the 12 Grade 4 classes (i.e. the learners' home environments and the school environments)?
3. What is the implemented curriculum as is evident in the classroom practices of the Mathematics teachers of the Grade 4 classes (i.e. that which teachers actually teach);
4. What is the attained curriculum for each class as manifested in Grade 4 learner achievement in Mathematics tests designed by TIMSS and matched to the intended curriculum (i.e. that which learners actually learn)? and
5. What is the relationship between all of these?

Because of the small sample of the pilot study, no conclusive answers to the 5th question were forthcoming, but the pilot provides valuable pointers to questions to be investigated more fully in a large-scale follow-up study.

5. Methodology

The most important data sources for the study were:

- school and teacher survey questionnaires These questionnaires established potential teaching and learning time in 1998, and identified which of the official and/or school curriculum documents, textbooks or other curriculum material each of the participating teachers intended using in planning their Mathematics teaching in the first term of 1998. Included in the teacher questionnaires was a questionnaire that established the extent to which teachers intended covering specific topics/subtopics in the first term. A further questionnaire established the actual coverage of the topics/subtopics at the end the term;
- pre-test/post-test (designed by TIMSS). The tests measured learner achievement before and after the teachers had covered particular Mathematical topics in their lessons. Twenty-five of the TIMSS items were selected. Eighteen items used a multiple-choice format. Six items required learners to provide their own answers. The content categories covered by the items included whole numbers (68%); patterns, relations and functions (24%); estimation (4%); and probability (4%).
- learner questionnaires. The questionnaires collected data on learner backgrounds and the change in their interest in and attitudes towards Mathematics;
- teacher and school questionnaires. These two questionnaires collected data on the social and educational context of each of the 12 schools such as teachers' academic and professional backgrounds, opportunities to learn etc.;

- lesson observations using an observation schedule and video recordings of Mathematics teaching. The primary purpose of the observation schedule was to assess the level at which teachers were able to engage learners with Math concepts and processes in terms of the following seven criteria -
 - Does the teacher explain the Mathematics concepts, principles and strategies to be learnt?
 - Does the teacher demonstrate how the Mathematics concepts, principles and strategies to be learnt work?
 - Does the teacher organise learner-learner discussion about the Mathematics concepts, principles and strategies to be learnt?
 - Does the teacher structure Mathematics activities through which learners experiment with using the Mathematics concepts, principles and strategies to be learnt?
 - Does the teacher provide learners with opportunities to participate in practising using the Mathematics concepts, principles and strategies to be learnt?
 - Does the teacher assess whether learners have learnt the Mathematics concepts, principles and strategies?

Secondary purposes of the observation schedule were to capture and describe a variety of 'outward forms' of teachers' teaching strategies, as well as the levels of learner participation in lessons. Thus, whole class teaching even when it involved occasional 'chanting' by learners, was rated as more effective than unstructured/unmediated group investigations.

The two research co-ordinators used the classroom observation instruments to observe each teachers' Mathematics lessons through at least one classroom visit during the first term. Video recordings and short units of translations of transcripts from the video recordings were made of each of the lessons. The recordings and transcripts were used for more in-depth analysis of classroom interactions, tasks and forms of assessment;

- structured interviews with teachers. The interviews provided background data on the lessons observed.

6. Research design

The analytical objectives of the study were the teachers' instructional practices and learner achievement. Thus the focus of the study was on trying to identify effective teaching strategies through an investigation into the relationship between the implemented curriculum and learner achievement at the Grade 4 level. Teachers and learners were the primary units of analysis for the study with schools sites as secondary units of analysis. Using the learners and teachers as the units of analysis was consistent with the goal of providing information about teacher's instructional practices, the performance of learners, and the relationship between the two.

The research design included:

- a pre- and post-tests design using the same selected items from TIMSS;
- testing twelve Grade 4 classes in nine schools,
- at least one observation of twelve Grade 4 Mathematics lessons in operation,
- twelve interviews with the sample of teachers; and
- a comparison of the pre- and post-test results.

7. Target population Sites

Nine schools with similar social and educational contexts were selected so as to maintain the focus on learner achievement and teachers' classroom practices. In other words, the researchers tried to select sites where the social and educational variables were as slight as possible so that any differences in learner achievement could be attributed to differences in the teaching methods used.

The main criteria for the selection of the sample of schools for the study was that the schools were generally representative of the majority of traditionally 'black' primary schools in urban areas in South Africa. (The physical resources at the schools were limited, the majority of learners came from working class and lower middle class socio-economic backgrounds and were not likely to acquire formal Mathematics knowledge at home). The schools were selected because they approximate the kinds of conditions that exist in the majority of urban township schools across South Africa.

Teachers

A sample of twelve Grade 4 Mathematics teachers was used. The sample comprised two teachers at three of the schools and one teacher at each of the remaining six schools. Three of the teachers were male and nine teachers female. All the teachers reported that they used English and Xhosa as the languages of teaching and learning in their Grade 4 Mathematics lessons.

Learners

An overall sample of 448 Grade 4 learners was used for the study. 48% of the sample were girls.

8. Research findings

The study of the intended curriculum

The study of the intended curriculum revealed that:

- all twelve teachers intended using the provincial Interim Syllabus for the Western Cape (1996) to guide their Grade 4 Maths program;
- all the teachers held a common intended curriculum. They all intended covering the same topics/subtopics;
- all the teachers intended using textbooks for their Grade 4 Maths teaching;
- there was considerable variation in the textbooks that the teachers intended using for their Grade 4 Maths teaching.

The study of the social and educational context

Data on the social and educational contexts for learning provided evidence:

- that the sample of schools, teachers and learners formed relatively homogenous groups,
- of key school and classroom variables and/or variables in teacher backgrounds that may be related to teacher effectiveness, or that could contribute to differences in learner achievement. For example, variables in school characteristics such as the number of minutes allocated to

Mathematics teaching per week; teacher characteristics such as teachers' experience, qualifications, and attendance at in-service programs; and variables in classroom characteristics such as learners' age ranges; class size, etc.

The study of the implemented curriculum

Data on the extent of coverage of the topics/subtopics identified in the study of the intended curriculum revealed:

- differences in the topics/subtopics covered by the teachers; and
- differences in the emphasis given to the topics/subtopics.

Data on the teaching strategies employed by the teachers revealed:

- the teaching strategies that were most frequently employed by the teachers. For example, eleven of the twelve teachers used whole class teaching to introduce, explain and/or demonstrate; none of the teachers grouped learners according to ability; most of the teachers used textbooks either to plan their lessons, or as sources for exercises in their lessons; and
- considerable variation in some of the strategies used. For example, the use of languages for teaching and learning; and the textbooks and other resource materials used.

Data on the level of learner participation in the lessons indicated that:

- the majority of learners appeared interested and attentive; and
- at least half of the learners in all classes appeared able to engage in the lesson at the levels required.

Data on the level at which teachers engaged learners with the Maths concepts and processes to be learnt provided evidence of:

- teachers themselves introducing incorrect forms of technical or Mathematical terms;
- variation in terms of the level at which teachers covered the topics/subtopics;
- teachers not addressing topics/subtopics in terms of increasing difficulty;
- teachers experiencing difficulty in engaging learners with Maths concepts and processes to a significant depth;
- teachers focusing on those aspects of the Maths concepts and processes that learners found easiest (for example, procedural issues such as arranging digits in the correct 'place', or basic operations such as addition and subtraction);
- teachers not proceeding to more complex procedures until all learners had mastered more basic procedures so that the pace and direction of lessons tended to be determined to a large extent by the weakest learners in the class;
- teachers not addressing, or experiencing difficulty emphasising more complex procedures (such as multiplication and division) and processes (such as problem-solving strategies, estimation, etc.);
- superficial coverage of Maths concepts and processes in lessons where teachers used real-life/everyday experiences as a context for teaching and learning; and

- teachers' having fairly low expectations of learners as a whole (in particular, what teachers expected learners to do with the Maths concepts and processes being taught was not cognitively demanding).

The study of the implemented curriculum also revealed that learners:

- were given few opportunities to practice using increasingly complex examples that assisted them to develop their understanding and use of Maths concepts and processes in progressively difficult ways;
- were not given opportunities to read, understand and use information or language provided in Maths texts, for example through translating word problem questions into number sentences,
- spent a large proportion of time practising work that they would/should have covered in the Foundation/Junior Primary Phase;
- in each of the classes all completed the same exercises/activities;
- who were coping and completed exercises/activities were not given the option of continuing with additional activities;
- were given few opportunities to discuss Mathematical concepts and/or processes, express their line of reasoning, or justify their thinking;
- responses to activities or exercises almost always took the form of numbers or numbers and Maths notation and little language; and
- were given few opportunities to apply Mathematical concepts, strategies or principles to real-life problems.

In particular, the study of the implemented curriculum provided evidence of:

- teachers being unable to address Mathematical processes such as problem-solving strategies, estimation, etc., or more complex procedures such as division and multiplication because learners lacked foundational Mathematical skills (such as skills in mental arithmetic) and conceptual understandings (such as an understanding of how the number system works);
- teachers introducing incorrect forms of technical or Mathematical terms because of confusion between teachers' and learners' primary language, the language of learning and the language of Mathematics;
- teachers experiencing difficulty in engaging learners with Maths concepts and processes to a significant depth because they did not understand the concepts and processes themselves; and
- teachers using textbooks as a source for exercises for lessons and, in some cases, to plan their lessons, but using textbooks in random, ad hoc ways that did not assist learners to:
 - a) develop or practice using Maths concepts and processes in terms of incremental complexity; and
 - b) read, understand and use text provided in Maths textbooks.

The study of the attained curriculum

No statistically significant improvement in learner achievement was evident in the pre- and post-test results of individual teachers' classes. However, overall learner achievement in specific items in the post-tests provided some indication of the majority of the Grade 4 learners' current knowledge base (cognitive skills and abilities) and experience in the Learning Area of Mathematical Literacy, Mathematics and Mathematical Sciences.

In particular, an examination of the sample of learners' responses to specific items in the post-tests indicated that most learners:

- had difficulty reading and understanding the language and information provided in TIMSS items tests, particularly in word problem questions;
- were unable to work efficiently because they did not know or lacked foundational competencies in Maths, in particular, competency in mental arithmetic (recalling number bonds and times tables);
- lacked a basic understanding of the number system, in particular, an understanding of place value;
- were unable to execute addition and subtraction algorithms which required "carrying" or decomposing
- were unable to explain or justify their answers or reasoning; and
- were unable to work with more complex procedures such as division, and estimation.

The relationship between the implemented curriculum, the intended curriculum, the social and educational context, and the attained curriculum. An analysis of the relationship between the intended curriculum and the implemented curriculum revealed discrepancies between the intended curriculum goals as expressed by teachers (at the end of 1997 and at the beginning of 1998), and the curriculum that teachers actually implemented during the first term of 1998. For example, some of the teachers did not address some of intended topics/subtopics at all.

Because of the small sample of teachers used in the pilot study, no conclusive answers to the relationship between variables in teacher backgrounds (such as teachers' qualifications) and teacher effectiveness emerged from the study. Nevertheless, data on the relationship between the social and educational context and the implemented curriculum indicated that:

- classrooms were subjected to many other extraneous influences and contextual variables;
- there may have been other aspects of the system that are failing;
- the social and educational context for learning and teaching is an important unit for analysis in curriculum reform processes, teacher training, and materials development.

No statistically significant improvement in learner achievement was evident in the pre- and post-test results of learners in individual teacher's classes. As a consequence, it was not feasible to analyse data in ways that made it possible to identify key variables that could have contributed to differences in learner achievement in TIMSS item tests.

However, an analysis of the relationship between overall learner achievement in the item tests and teachers' instructional practices suggests that more attention needs to be paid to developing:

- Maths language. For example, by - providing learners with opportunities to engage with Maths texts (i.e. to read, understand and use information or

language provided in Maths texts); deliberately teaching carefully-defined Maths terms and definitions; and making differences between learners' everyday language, the language of learning and new Maths language explicit.

- learners' Mathematical communicative competence. For example, through teachers - encouraging learners to explain or justify their answers or reasoning in writing; actively eliciting explanations from learners; using whole class discussion to elicit learners' understandings; asking learners to present their answers and thinking to the whole class; involving the whole class in deciding on the best solution/s, etc., and
- Maths content at more appropriate levels of cognitive complexity. For example, through teachers engaging learners in using increasingly complex examples that assist them to develop their understanding and use of Maths concepts and processes in progressively difficult ways.

9. Recommendations

The Study's findings appear to support the view that, if the curriculum goals of Curriculum 2005 are to be implemented and achieved, (i.e. Mathematical processes such as problem-solving strategies, estimation etc. are to be emphasised), then strategies are required which:

- provide all learners with increased opportunities to acquire a core of foundational competencies in Maths (for example, basic Mathematical skills such as number bonds and multiplication tables, and basic conceptual understandings, for example base 10 and place value); and
- ensure maximum use is made of available teaching time to improve Maths learning by
 - a) creating more effective instructional conditions; and
 - b) creating conditions that will ensure that teaching time is used more efficiently and purposefully.

The recommendation of the study is that strategies include developing:

1. a curriculum framework that makes the core content (Maths discipline knowledge) that teachers must cover explicit. This would ensure consistency in implementation of the new curriculum in terms of coverage of content;
2. clearly-stated performance standards that outline the levels at which learners in the different grades are expected to perform, and the levels at which teachers should cover and assess Maths content. This would ensure consistency in the level of implementation and achievement in terms of levels of cognitive complexity/difficulty;
3. resource materials that provide teachers and learners with a 'bridge' which mediates between what is intended, and what is currently being implemented in classrooms; and
4. professional teacher programs that are directed at assisting teachers to implement and achieve the outcomes for learners. In particular, pre- and inservice teacher education and training that:
 - develops teachers' own knowledge and understanding of Maths concepts and processes so that they are more able to engage learners with Maths content at appropriate levels (i.e. levels which are in line with the

performance standards), and identify which learners possess adequate knowledge and skills;

- develops teachers' knowledge and understanding of language in Maths teaching.

Research Recommendations

The Focus on Four study goes some way towards establishing relationships between teachers' instructional practices and learner achievement. However, the use of TIMSS items did not allow for statistically significant evidence of improvement in learner achievement to emerge. As a result, no conclusive evidence of the effect of teachers' instructional practices on learner achievement could be identified.

A recommendation is that the work started by this research project be continued, and that test items for a follow-up investigation be developed and validated through a battery of field tests and a series of statistical checks. This would ensure that the items selected are good discriminators of:

- a) learners' Mathematical ability; and
- b) the effect of teachers' instructional practices on Grade 4 Mathematics learners in the South African context.

1. INTRODUCTION

1.1 Background and Aim

The research for this report was commissioned by the President's Education initiative, through the National Department of Education (DoE).

This report documents Focus on Four (December 1997 - June 1998), an investigation into learner competence in Grade 4 Mathematics in certain schools; the classroom strategies employed by the teachers of these learners; and any possible links between teaching/learning strategies and learner achievement.

The research model for the study is based on the Third International Mathematics and Science Study (TIMSS) (1996), a research project sponsored by the International Association for the Evaluation of Educational Achievement (IEA). The TIMSS provides a model for the Focus on Four research in that it represents international consensus on curricular aims in Mathematics. The Study also provides an array of instruments for measuring Mathematical achievement by learners.

In 1994-5 TIMSS measured learner achievement in Mathematics and science at three levels of the school system in over 40 countries of varying levels of economic development. Learner achievement for TIMSS was measured through written tests approved by all participating countries. The tests were developed through a process of international consensus involving extensive input from Mathematics educators and other experts in Mathematics. Included in the written tests are items that measure learners' ability to apply their knowledge and skills in non-routine settings.

Underpinning the design of TIMSS is a range of interconnected contextual variables that may contribute to learner achievement. Thus instrumentation for TIMSS includes context (school, teacher and learner) questionnaires designed to elicit information on learner and teacher backgrounds, school and classroom variables, school climate, learners' opportunity to learn, time on task etc. The design allows for collection and comparison of data on variations such as

- teachers' academic and professional training;
- the use of technology in Mathematics teaching,
- the influence of textbooks on Mathematics teaching and learning, and
- the attitudes and opinions of learners and teachers.

In preparation for the research, the Focus on Four research co-ordinators reviewed a number of TIMSS documents (see References).

The review of TIMSS literature revealed that TIMSS research design has enormous potential as a model for a study such as Focus on Four where the goal is:

- a) to provide insights into the Mathematics achievement of Grade 4 learners; and
- b) to make suggestions as to how improvement in learners' Mathematics achievement at this level might be attained through teachers' instructional practices.

This report on the Focus on Four study provides:

- the background, aims and objectives of the study including links with the Western Cape Education Department, and other research initiatives in South Africa and overseas;
- a detailed description of the research design and methods, including the names and a description of the sites and samples, and the criteria for selecting the sites and samples,
- a description of the Math knowledge and performance requirements of Grade 4 learners set out in the government curriculum documents used by the sample of teachers,
- a description of the Math knowledge and performance requirements in TIMSS;
- a comparative analysis of the Math knowledge and performance requirements set out in official curriculum documents and TIMSS;
- the criteria used in TIMSS to measure improvement in the level of learners' Mathematical achievement;
- the instruments developed for assessing learner achievement and teachers' implementation strategies in terms of the criteria;
- an overview of the training of fieldworkers and the testing of the item tests;
- the results of the preliminary investigation of the sites;
- a detailed description of the fieldwork;
- data analysis and interpretation;
- main findings and conclusions; and
- lessons learnt and recommendations for future research.

1.2 Purpose, aim and rationale for the study

South Africa is currently involved in a process of major curriculum reform, Curriculum 2005. Underlying this curriculum reform initiative are important shifts in terms of philosophies and attitudes towards knowledge and teaching and learning. In particular, the new Curriculum 2005 proposes specific outcomes which outline the knowledge, skills and attitudes to be evidenced by learners in various Learning Areas. These specific outcomes signal a shift away from traditionally content-based outcomes towards knowledge and skills-based outcomes. However, achieving the knowledge and skills-based outcomes for learners outlined in Curriculum 2005 will of necessity require that teachers employ the kinds of teaching strategies linked to learner attainment of the new outcomes.

One of the assumptions of Curriculum 2005 is that teachers should change their teaching approach from an approach that focuses on rote learning and factual recall to an approach that emphasises conceptual understanding, skills and values. What is not yet clear is which teaching strategies are effective in relation to the new learning outcomes. While Curriculum 2005 planners advocate forms of learner-centred methodologies, there appears to be a lack of secure knowledge as to what constitutes effective learner-centred approaches and their appropriate deployment (ref JET Bulletin No. 7 October 1997; Adler, 1997).

The purpose of the Focus on Four study was to investigate Grade 4 learner attainment of particular Mathematics outcomes, and the teaching practices and pedagogical processes effective in terms of facilitating these learning outcomes. The investigation took the form of a micro study of the ways 12 teachers are teaching Grade 4 Mathematics and of the ways in which learners in these classes are learning. The analytical objectives of the study are to focus on teachers' instructional practices and learners' Mathematics achievement. Learner achievement was measured in terms of growth in learners' understanding and application of whole number, and estimation and number sense; their problem solving abilities; and their attitudes towards Mathematics. The researchers tried to establish causal links between teachers' classroom practice and learner achievement in item tests and learner attitudes towards Mathematics.

The aim of the study therefore, was to try to identify those teaching practices and pedagogical processes which may be effective in terms of improving the quality of learning outcomes related to the Mathematical Literacy, Mathematics and Mathematical Sciences Learning Areas of Curriculum 2005.

The nine schools selected for the study were all former DET schools located in established townships near Cape Town. The schools were selected because they approximate the kinds of conditions that exist in the majority of urban township schools across South Africa. This is not to simplify the wide diversity that exists between individual schools within townships, but rather to locate the study firmly within a major sector of the diverse types of schools that exist in the country.

The rationale for focusing the study on Grade 4 is that it is at this level that important shifts are expected to occur in terms of the level of learners' Mathematical understanding and abilities. For example, significant shifts are expected to occur in their ability to:

- ✍ estimate and calculate mentally instead of relying on concrete or physical representations (such as number charts, counters, etc.);
- ✍ understand and use more indirect and formal Mathematical abstractions or representations (specialised Mathematical notation and symbols) and procedures such as algorithms,
- ✍ restate real-life problems in terms of abstract/symbolic Mathematical representations and procedures;
- ✍ generalise Mathematics concepts, principles, or strategies so as to solve new and unusual problems and solve familiar problems in new and unusual ways.

In other words, it is at this level that crucial shifts in the levels of learners' formalisation of Mathematical knowledge and skills are expected to take place. By implication, the teacher's mediation of particular Mathematical knowledge and skills becomes critical, particularly for learners who are unlikely to acquire such knowledge and skills at home.

The intention of Focus on Four is to investigate the pedagogical processes and teaching practices that best facilitate these kinds of outcomes under the conditions existing in the sample of schools, through an analysis of:

- the intended Mathematics curriculum for Grade 4 learners, as stated in official curriculum documents and as reflected in the textbooks and other curriculum material used by the teachers,
- differences and similarities in the social and educational contexts for learning; • the implemented curriculum as is evident in the 12 Grade 4 Mathematics teachers' instructional practices;
- the attained curriculum, as manifested in the Grade 4 learners' achievement in Mathematics item tests matched to the intended curriculum, and
- the relationship between all of these.

1.3 The context of the study

In order to put the study into perspective, it is useful to outline the context of the study in terms of the people and processes involved in setting up the project, such as the:

- research co-ordinators (see 1.3.1);
- fieldworkers (see 1.3.2);
- timing of the research (see 1.3.3);
- organisation and administration of the research (see 1.3.4);
- links formed with the Western Cape Education Department, and other research initiatives in South Africa and overseas (see 1.3.5).

1.3.1 The researchers

The two research co-ordinators for Focus on Four were Caroline Long and Cheryl Reeves.

Caroline Long has, over a period of 15 years, taught Mathematics at a range of levels from pre-school to matric, in both formal classroom situations and in less formal situations. She has also written and edited textbooks ranging from Grade 1 to Grade 9 and written Math materials for ASECA, a distance learning project. In 1995 she was temporarily employed at the Cape Town College of Education as a lecturer. At the Primary Open Learning Pathways Trust, she was responsible for teaching the Mathematics component to in-service teachers and for monitoring in-service teacher practice. She has a B.Ed (Remedial Education) from Witwatersrand University, and completed an M.Ed in Mathematics Education in 1995 at the University of Cape Town. At present she works as an independent researcher.

Cheryl Reeves has been a high school teacher for ten years. She has also worked as a volunteer adult educator for the Adult Learning Project. In 1991 she conducted interviews and prepared the manuscript for 'The Struggle to Teach' for SACHED Trust's Publishing Project. More recently she co-ordinated the development and evaluation of an in-service diploma for junior primary teachers through distance education for the Primary Education Project. She assessed the impact of two of the Project's courses on teachers' understandings and classroom practice. In 1997, she worked as a researcher for the Primary Science Textbook Project at

the University of Cape Town. She has a Masters degree from UCT and currently works as a freelance educational researcher.

1.3.2 The fieldworkers

Focus on Four fieldworkers had as their main tasks.

- translating the learner item tests and questionnaire from English into Xhosa;
- administering the school questionnaire to the school principals and the teacher questionnaire to the Grade 4 class teachers,
- administering the learner tests and questionnaire to Grade 4 learners at 12 schools;
- completing a fieldworker questionnaire after testing each class,
- collecting the completed teacher and school questionnaire after administering the tests,
- marking and recording the results according to a coding schedule;
- assisting with translation during lesson observation, and
- assisting with transcriptions of videos of teachers teaching.

Fieldwork was closely monitored by the research co-ordinators.

In November 1997 Focus on Four advertised for fieldworkers/ translators at the University of Cape Town and the University of the Western Cape. The advertisement invited post-graduate students or final year B. Prim Ed. students to apply for the part-time fieldwork. Fieldworkers needed to be available to visit schools during official school hours at the end of January or the beginning of February, and again at the end of March. As the primary language of most learners at the sample schools is Xhosa, and TIMSS item tests needed to be translated from English, the project required students fluent in English and Xhosa.

The four fieldworkers/translators contracted during the course of the study were Bongani Ntyintyana, Thembilizwe Qolo, Lubabalo Dzedze and Lizo Qangule.

Bongani Ntyintyana completed his B. Prim. Ed at UCT in 1997. He is registered for a part-time B.Ed at UCT in 1998. He has worked part-time for SHAWCO (UCT) as a Mathematics tutor for adult education, and as a resources assistant for the Mathematics Education Project (MEP), UCT. His particular interest is Mathematics teaching and learning at the primary level. His task was to assist Focus on Four with the translation of item tests and the learner questionnaire.

Thembilizwe Qolo has a B.A. (Honours) degree and is currently completing his M. A. Research Psychology degree at the UWC. He has worked as an English second language and guidance teacher, and as a SADTU site steward. He has assisted UWC's Centre for Adult and Continuing Education with translation and data collection through interviews. In 1997 he conducted research for the Western Cape Community Partnership Project. His task was to administer the item tests and the school, teacher and learner questionnaires.

Lubabalo Dzedze has a B.A. degree and a Postgraduate Diploma in Library and Information Science from the University of Cape Town. During the 1996 Census he worked as Chief Enumerator for the Central Statistical Services (Cape Town). In 1997 he assisted the Triple Trust Organisation with data collection and research work. He has also participated in research for the Cape Town City Council's Arts and Culture Policy Development task team and is a member of the Parliamentary Monitoring Group. His task was to administer the learner questionnaires and item tests. He also assisted with translation of the lessons observed.

Lizo Qangule has a B. Soc. Sci. degree from the University of Cape Town. He assisted with administering the learner questionnaires and item tests.

1.3.3 The timing of the research

Data collection took place during the first term of 1998, between the last week of January and the last week of March.

Administration of learner tests and questionnaires took place between 26 January - 3 February and again between 18 - 26 March 1998. Tests were administered as early in the first term as possible before learner achievement could be influenced by the Grade 4 teachers' teaching. The same tests were administered for the second time as near to the end of the first term as was practicable, so that any influences of the implemented curriculum could be measured.

Classroom observation and teacher interviews took place between 2 February - 18 March 1998.

1.3.4 Organisation and administration of the research

Focus on Four is one of the classroom-based research projects managed by the Joint Education Trust (JET) and funded by the President's Education Initiative. The project is accountable to JET and the National Department of Education.

1.3.5 Links with the Western Cape Education Department and other research initiatives in SA and overseas

Links with the Western Cape Education Department

Approval to conduct the Focus on Four research in schools in the Western Cape was granted by the Western Cape Education Department subject to the following conditions:

- the principals, teachers and learners are under no obligation to assist in the investigation;
- the principals, teachers, learners, and schools should not in any way be able to be identified from the results of the investigation;
- all arrangements concerning the investigation should be done by the researchers personally;
- the investigation should not be conducted during the fourth school term;

- the above conditions should be submitted unamended to the school principal where the intended research is to be conducted; and
- a brief summary of the content, findings and recommendations and a copy of the completed report should be provided to the Director: Curriculum Management (Research Section).

In addition to obtaining approval from the Department, the Focus on Four researchers established links with the following officials from the Department:

- Dr Nico Farson, Head of Research,
- Mr Hennie Mentz, Head of Education, Curriculum Services;
- Dr Mike Cameron, Subject Advisor for Mathematics;
- Esme Passman, Principal Subject Advisor for the Intermediate Phase; and
- Mr J A Cicero, Circuit Manager, West Coast Area.

Links with other research initiatives in South Africa

In order to establish complementary relationships, to avoid duplication, and keep informed about similar research initiatives in the Western Cape and elsewhere, Focus on Four research co-ordinators contacted and/or met the following individuals:

- Derek Gray, who was the South African Co-ordinator responsible for TIMSS South Africa, and Colleen Hughes, who is currently involved in HSRC research linked to TIMSS;
- Professor Dirk Mørkötter and Professor Cyril Julie who are co-ordinating Curriculum 2005 research projects at the Faculty of Education, University of Western Cape,
- Professor Douglas Young and Ms Jean Baxen who are co-ordinating Curriculum 2005 research projects at the School of Education, University of Cape Town; and
- Jean Pease of the Primary Open Learning Pathways, and Lynn Rousseau of the Primary Math Project, who are currently conducting classroom-based research.

Links with overseas research initiatives

The researchers communicated with the following individuals via email:

- Brian Thomson and Michael Martin of the International Study Centre, Boston College in order to get information about TIMSS, lists of publications, research protocol regarding use of TIMSS instruments, and the names of IEA contacts,
- Hans Wagemaker, Executive Director, the International Association for the Evaluation of Educational Achievement in the Netherlands in order to clarify the protocol around using TIMSS item tests in the research.

2. FOCUS ON FOUR RESEARCH MODEL AND QUESTION

2.1 The research model

The research design for Focus on Four is derived from TIMSS Curriculum Framework for Mathematics and TIMSS research model.

2.1.1 TIMSS Curriculum Framework for Mathematics TIMSS Curriculum Framework is designed to guide:

- the development of appropriate instrumentation for assessing learner achievement in Mathematics; and
- the analysis of official and/or school curriculum documents, textbooks or other curriculum material.

In particular, the Framework is designed to provide a guide for developing or describing any 'piece' of curriculum (e.g. an item test, a section of text from a textbook, a paragraph from a curriculum guide) in terms of three aspects or parameters (p.42 TIMSS Monograph No 1). These aspects are:

- a content aspect representing the topic or subject matter;
- a performance expectations aspect representing the expected learner performance or the kinds of performances or behaviours that the test item or piece of text (content) might be expected to elicit from the learner;
- a perspectives aspect representing the values underlying tasks, and the development of learners' interest in and attitudes towards Mathematics.¹

Table 1 below provides the major categories of these three aspects of TIMSS Mathematics Framework.

TABLE 1: THE THREE ASPECTS AND MAJOR CATEGORIES OF THE MATHEMATICS FRAMEWORK

CONTENT ASPECT	PERFORMANCE EXPECTATIONS ASPECT	PERSPECTIVE ASPECT
<ul style="list-style-type: none"> • Numbers • Measurement • Geometry: position ... • Geometry: symmetry ... • Proportionality • Functions, relations, equations • Data, probability, statistics • Elementary analysis • Validation and structure • Other content 	<ul style="list-style-type: none"> • Knowing • Using routine procedures • Investigating and problem solving • Mathematical reasoning • Proportionality • Communicating 	<ul style="list-style-type: none"> • Attitudes • Careers • Participation • Increasing interest • Habits of mind

TIMSS Monograph No 1, p46.

The content aspect of the Mathematics Framework consists of ten categories. The performance expectations aspect consists of six

¹ Obviously, not all 'pieces' of curriculum necessarily reflect all three of these aspects.

categories including processes of inquiry such as 'investigating and problem-solving'. The perspectives aspect consists of five categories. A detailed list of all the sub-categories within TIMSS Mathematics Framework categories is included in Appendix E.

2.1.2 The TIMSS research design

The research design for TIMSS includes data on curricular content at the

- ? system level (the intended curriculum);
- ? school/classroom level (the implemented curriculum),
- ? and learner level (attained curriculum).

Curricular content at the system level consists of the intended curriculum or the Mathematics content (subject matter or topics, expected learner performance, and attitudes) as defined at the national or educational system level.²

Curricular content at the school or classroom level consists of the implemented curriculum or the Mathematics curriculum as interpreted by teachers and made available to learners.³

Curricular content at the learner level consists of the attained curriculum or the three different levels of content - the concepts, processes, and attitudes towards Mathematics, which learners exhibit.

However, also central to the research design is the role that the curriculum and contextual variables (for example, school system arrangements and learners' home background variables) play in differences in individual learner achievement.

Thus, in addition to data on curriculum content the research design for the study includes data on:

curricular antecedents or the societal and educational contexts in which the school system operates at the system level, the school or classroom level (for example, community, school, and teacher characteristics such as age, qualifications, etc.) and the learner level (for example, learner background, age etc.); and

curricular contexts or educational contexts at the system level (for example, institutional arrangements); at the school or classroom level (for example, school and classroom conditions and processes); and at the learner level (for example, learner experience in the educational context).

² The TIMSS collected information about the intended curriculum through an analysis of textbooks, curriculum guides and other curricular materials.

³ Teachers in TIMSS provided information related to the implemented curriculum by describing their instructional methods and the time spent teaching the Mathematics topics in TIMSS curriculum framework.

2.2 Focus on Four research questions

The research questions for Focus on Four are derived from four questions formulated for TIMSS as guidelines in designing TIMSS and in developing the instrumentation used. The TIMSS questions have been adapted so that they can be related to learner achievement in item tests before and after the sample of teachers had covered a particular Mathematics topic in their Grade 4 Mathematics classes, and to relationships between teachers' classroom practices and learner achievement.

The following are the research questions formulated for the Focus on Four study:

1. What is the intended curriculum for Grade 4 Mathematics learners in 12 Grade 4 classes in the first term of 1998 (i.e. that which the teachers intend to teach)?
2. What are the variables in the social and educational contexts for learning in the 12 Grade 4 classes (i.e. the learners' home environments and the school environments)?
3. What is the implemented curriculum as is evident in the classroom practices of the Mathematics teachers of the Grade 4 classes (i.e. that which teachers actually teach);
4. What is the attained curriculum for each class as manifested in Grade 4 learner achievement in Mathematics tests designed by TIMSS and matched to the intended curriculum (i.e. that which learners have actually learned)?; and
5. What is the relationship between all of these?

3. FOCUS ON FOUR RESEARCH DESIGN

The analytical objectives of the study were to focus on teachers' instructional practices and learner achievement. Thus the focus of the study was on trying to identify effective teaching strategies through an investigation into the relationship between the implemented curriculum and learner achievement at the Grade 4 level. Teachers and learners are the primary units of analysis for the study with schools sites as secondary units of analysis. Using the learners and teachers as the units of analysis was consistent with the goal of providing information about teacher's instructional practices and performance of learners, and the relationship between the two.

The design for the research included:

- a pre- and post-tests design using the same selected items from TIMSS,
- testing twelve Grade 4 classes in nine schools;
- at least one observation of twelve Grade 4 Mathematics lessons in operation,
- a comparison of the pre- and post-test results;
- twelve interviews with the sample of teachers.

3.1. Sites and sample selected for the study

Sites

Nine schools with similar social and educational contexts were selected so as to maintain the focus on learner achievement and teachers' classroom practices. In other words, the researchers tried to select sites where the social and educational variables were as slight as possible so that any differences in learner achievement could be attributed to differences in the teaching methods used.

The main criteria for the selection of the sample of schools for the study was that:

1. The schools are generally representative of the majority of traditionally 'black' primary schools in urban areas in South Africa. (The physical resources at the schools are limited, and the majority of learners come from working class and lower middle class socio-economic backgrounds and are not likely to acquire formal Mathematics knowledge at home);
2. Conditions at the schools are such that formal teaching and learning is able to take place on a regular basis. (The schools have functioning timetables, and a general culture of teaching is prevalent at the schools);
3. The schools are clustered within easy travelling distance for the fieldworkers and researchers and are contactable so that suitable times for visits could be arranged;
4. The primary language of the majority of learners at the schools is Xhosa (the item tests had been translated into Xhosa and English and the fieldworkers are fluent in English and Xhosa); and
5. Principals and teachers at the schools indicated a willingness to participate in the study.

A survey questionnaire developed to establish the potential teaching and learning time at the schools in 1998 was administered to school principals, deputies or HoDs in November 1997 and January 1998 (see Appendix A).

Table 2 below provides information on the potential teaching and learning time for Grade 4 learners as reported by the schools

TABLE 2: TEACHING AND LEARNING TIME AT THE SCHOOLS IN 1998

School	No periods / day	Length of periods (mins)	No. Grade 4 Maths periods / week	No hrs average school day	School starting time	School closing time	Days which differ	Closing time on these days	School breaks	Extra-mural activities during school time	Grade 4 exam in the first term	Grade 4 exam period in first term	No of exam days
1	11	30	7	6 ½	08h00	14h30	Thurs & Fri	14h00 12h30	09h45 - 10h00 11h55 - 12h25	Wed last 2 periods	No	N/A	N/A
2	10	30	7	6 ½	08h00	14h30	N/A	N/A	10h15 - 10h30 12h00 - 12h45	Yes	Yes	last 2 weeks	6
3	10	30	7	6	08h00	14h00	Fri	13h00	10h15 - 10h30 12h00 - 12h45	Yes	No	N/A	N/A
4	10	30	8	6	08h00	14h00	Fri	13h00	10h40 - 11h00 12h30 - 13h00	Yes	No	N/A	N/A
5	10	30	10	6 ½	07h50	14h30	Fri	12h30	10h00 - 10h10 12h10 - 12h30	No	No	N/A	N/A
6	10	30	9	6	08h15	14h15	Wed & Fri	13h15	10h00 - 10h15 11h45 - 12h45	No	No	N/A	N/A
7	10	40	9	6	08h00	14h00	Wed & Fri	12h00	10h00 - 10h30 11h45 - 12h15	No	No	N/A	N/A
8	10	30	10	6h20	08h00	14h20	Fri	13h00	10h00 - 10h20 11h00 - 11h30	No	No	N/A	N/A
9	10	30	10	6	08h00	14h00	N/A	N/A	10h10-10h20 11h00-11h30	No	No	N/A	N/A

..... data not provided

N/A not applicable

Data on teaching and learning times for Grade 4 learners at the sample schools in 1998 revealed that the average school day at all the schools is comprised of between 6 - 6 1/2 hours. Seven of the nine schools reported that they started at 08h00, one at 08h15 and one at 07h50 every day. Four of the schools reported that they closed at 14h00, three at 14h30, one at 14h15 and one at 14h20 on most days. Seven of the schools reported that they closed earlier on Fridays. According to the reports extra-mural activities occasionally take place during the school day at four of the 8 schools.

All the schools in the sample reported that they have timetables that operate on a 5 day cycle. School days at all the schools are divided into 10/11 instructional periods of 30/45 minutes each. According to the initial survey the number of hours of Mathematics lessons that Grade 4 learners had per week is 3 1/2 hours at three of the schools, 4 hours at one school, 4 1/2 hours at one school, 5 hours at 3 schools and 6 hours at one school.

According to the survey, Grade 4 examinations were to be administered in the first term of 1998 at only one of the schools, school 2. Examinations at this school were to take place during the last 2 weeks of the term over a period of approximately 6 instructional days.

Procedures used for obtaining the co-operation of schools and teachers entailed contacting the schools and setting up meetings between the researchers and the school principals or deputies, relevant Hods and teachers. A number of meetings took place at the schools. The research co-ordinators provided the schools with background information on the research including:

- the organisations involved in sponsoring and managing the research;
- TIMSS, its significance as a research model, and some of the findings of the international study;
- details regarding approval from the Western Cape Education Department to conduct the research and the specified conditions;
- the Focus on Four research, its purpose, aims and research design;
- what the school's participation in the investigation would involve; and
- the type of feedback schools would receive in terms of the research (the final report would be made available to schools).

The researchers emphasised that participation in the investigation was entirely voluntary, with the schools themselves deciding whether or not to participate in the study. The responses of the staff to these meetings were extremely positive, with Grade 4 Mathematics teachers and principals or deputies at all the schools expressing a willingness to make a commitment to participation in the research.

Teachers

Initially a sample of six teachers was selected for the study. Negotiations with these teachers took place at the end of the fourth term in 1997. However, on the advice of Professor Johan Mouton of the Centre for Interdisciplinary Studies, Stellenbosch University, about strategies for including statistical data analysis techniques in the data analysis the researchers decided to increase the sample size to twelve teachers. Six additional teachers were identified in the first week of the first term of 1998.

However, some schools were only able to establish which teachers at the school were to be re-deployed or retrenched after the first term of 1998 had begun. Changes in the staff ratio affected the allocation of classes at the Grade 4 level in some of the sample of schools. This meant that the researchers had to make further adjustments in terms of the original sample of teachers selected for the study after the beginning of the first term.

In spite of the above constraints the researchers were able to maintain a sample of twelve Grade 4 Mathematics teachers. The sample is comprised of two teachers at three of the schools and one teacher at each of the remaining six schools. Three of the teachers are male and nine teachers are female. All the teachers reported that they used English and Xhosa as the languages of learning in their Grade 4 Mathematics lessons.

Learners

The population level of learners sampled for the Focus on Four study is defined in terms of Grade 4⁴ and the unit of sampling is intact Grade 4 classes.

As a large percentage of learners at former DET schools are reportedly over the expected age for these grades, a grade-based definition rather than an age-based definition is used for the Focus on Four study. However, a grade-based definition does not necessarily mean that all Grade 4 learners have received the same number of years of formal schooling. A large percentage of learners may have repeated classes and others may have dropped out and returned. Thus all Grade 4 learners were tested regardless of their age or the number of years of schooling they may have had.

Using intact classes as the unit of sampling yielded a sample of at least 27 learners in each class (depending on the class size) and an overall sample of 448 Grade 4 learners. This approach enabled the researchers to compare overall learner achievement among classes based on the average percentage of correct responses to

- all the written item tests; and
- individual items/subsets of test items.⁵
- 48% of the sample were girls.

⁴ The first level of learners measured by TIMSS included learners enrolled in the two adjacent Grades that contained the most learners aged nine at the time of testing. For most countries this meant testing learners in Grades 3 and 4. In the South African system Grades 3 (std 1) and 4 (std 2) are the two Grades in which learners are expected to attain the age of nine. The two other levels measured for TIMSS include the grades at which most learners attain the ages of thirteen, and the grade at which most learners are completing their last year of secondary schooling.

⁵ In addition to written tests TIMSS developed a set of carefully-designed performance assessment tasks to be used with random smaller subsamples of learners within classes. These performance tasks are designed so as to allow for the assessment of learners' performance in terms of their conceptual understanding and problem-solving strategies, a mode of assessment congruent with the goals of Curriculum 2005. However, administering such tasks would require additional resources and time (for example, items of equipment such as calculators). Given the research timeframe, and material and human resources available for the Focus on Four research, it was not possible to administer these tasks effectively to a large enough number of subsamples. Nevertheless, the performance tasks developed by TIMSS do present a viable option for future research.

3.2 Data sources for the study

3.2.1 The intended curriculum

The intended curriculum in TIMSS is comprised of the learning goals specified at the national or regional level, the school level, and the classroom level. Thus the intended curriculum for Focus on Four is reflected in the official curriculum documents, the curriculum topics or areas that the sample teachers intended covering in the first term of 1998, and the textbooks and other curricular material teachers intended using in their Mathematics teaching. A detailed description and analysis of the intended curriculum is provided in Section 4 of the Report.

3.2.1.1 Official curriculum documents

The Focus on Four researchers studied the following official curriculum documents.

- Curriculum 2005 (March 1997); and
- the Junior Primary and Senior Primary Interim Syllabi for the Western Cape (1996).

3.2.1.2 Other sources of information

In addition to studying available official curriculum documents, the researchers asked all the teachers to complete an identical survey questionnaire (see Appendix B) in November 1997 and January 1998 and identify:

- which official curriculum documents they intended to use to guide their Grade 4 Mathematics programme in 1998;
- the curriculum topics or areas they intended to cover in the first term;
- the textbooks and other curricular material they intended to use; and
- the language/s of instruction used in their Grade 4 Mathematics lessons.

Official curriculum documents used to guide teachers' Grade 4 Mathematics programme in 1998

The survey questionnaire asked teachers to indicate which of the following official curriculum documents they would use to guide their Grade 4 Mathematics programme in 1998.

- Curriculum 2005,
- Interim syllabus for the Western Cape (1996);
- Departmental teacher guides;
- the school's own written statement of curriculum content; and
- other documents.

Curriculum topics or areas covered by teachers in the first term

The Focus on Four researchers initially asked a number of Grade 4 teachers about the Mathematics topics Grade 4 teachers were likely to cover in the first terms of 1998. Based on feedback from these teachers and the list provided in TIMSS Framework, the following Mathematics topics were selected for the survey questionnaire assessing teacher's content (topic) goals:

- Whole numbers,
- Estimation and Number Sense,

- Problem Solving Strategies.
- Common fractions;
- Decimal fractions;
- Measurement Units and Processes; and
- Estimation and Error of Measurements;

The teachers were also requested to indicate the estimated number of lessons in which the topic would be covered. Four choices were provided for each topic: 1 - 5 lessons, 6 - 10 lessons; and more than (>) 15 lessons.

3.2.2 Social and educational contexts

In order to collect data on the social and educational contexts for learning, Focus on Four fieldworkers administered a school, teacher and learner questionnaire at each school. The three questionnaires were adapted from TIMSS questionnaires which were designed to collect complementary information on local, community, school and learner contexts. All three of the questionnaires were administered in the first term of 1998.

3.2.2.1 The school questionnaire

The school questionnaire was designed to collect information on enrolment and demographics as well as institutional and instructional arrangement at schools. The principals or deputies or an HoD at each of the sample schools were asked to respond to the questions (see Appendix D).

3.2.2.2 The teacher questionnaire

The teacher questionnaire was designed to collect background information about teachers such as their qualifications, age, gender, years of teaching experience, etc. (see Appendix C). Each of the sample teachers was asked to respond to the questions.

3.2.2.3 The learner questionnaire

The TIMSS conceptual model of learner achievement identified the following learner characteristics for consideration:

- background;
- socio-economic status of family;
- cultural capital of family including academic expectations;
- learner attitudes towards Math;
- teacher and peer influence in Math; and
- time spent on Mathematics outside of school.

Thus, in addition to collecting data on learner attitudes and self-concept in Mathematics, the learner questionnaire (see Appendix G) collected descriptive information about learner backgrounds and their home and social environment (for example, whether English is spoken at home, the educational resources at home, the academic expectations of their friends, etc.)

3.2.3 The implemented curriculum

The implemented curriculum according to TIMSS is the opportunity to learn (OTL) that is made available to learners in the classroom.

The model for studying the implemented curriculum used by Focus on Four was developed by the Survey of Mathematics and Science Opportunities (SMSO). The SMSO was a developmental research study formed by TIMSS in order to develop instruments that could inform cross-national differences in learner attainment in TIMSS.

From 1991 to 1993, the SMSO conducted over 120 classroom observations across six countries (France, Japan, Norway, Spain, Switzerland, and the United States). The study's lesson observations focused on the Math and science classes of nine and thirteen year-old learners in each country (Schmidt, H et al, 1996:x).

The SMSO conceptual framework for studying the implemented curriculum is represented in the following diagram:

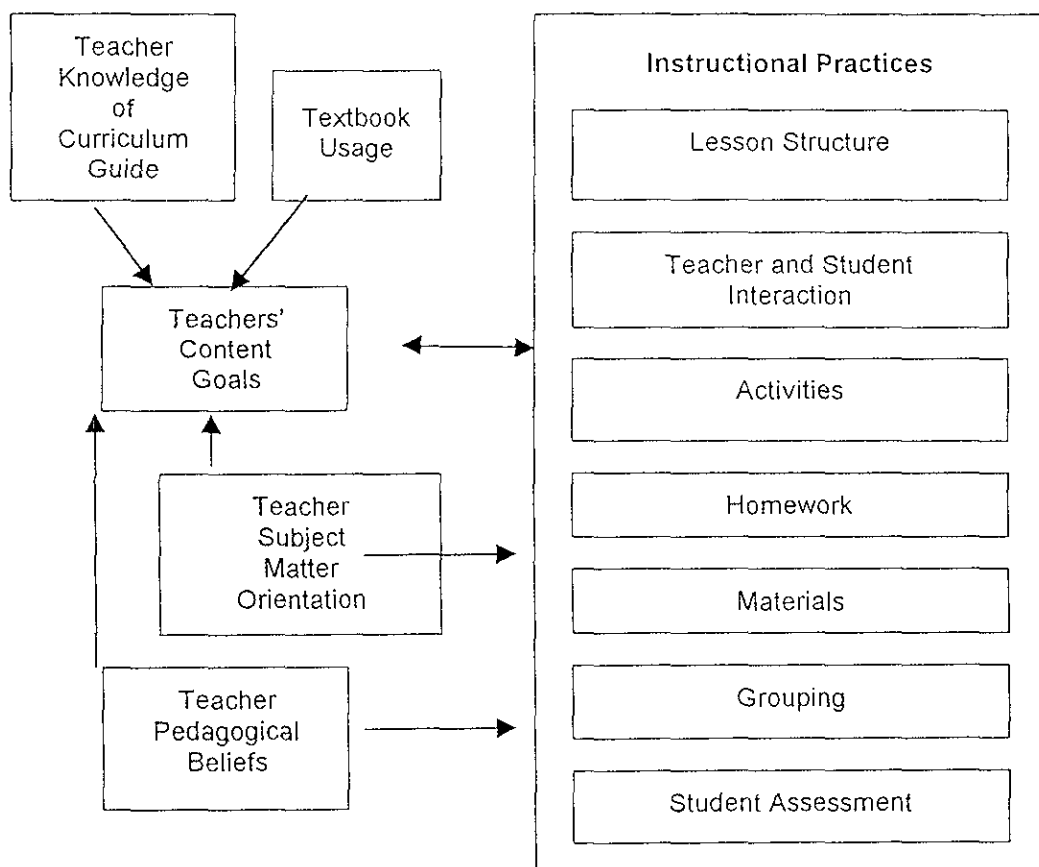


Figure 1: Conceptual Framework: Implemented Curriculum

(Schmidt, W.H. et. al., 1996:22)

The implemented curriculum for the Focus on Four study has been operationalised as the opportunity made available to learners to achieve the content and performance expectations tested in the item tests through teachers' classroom practices. This was done through classroom

observation (see 3.2.3.1) a teacher interview (see 3.2.3.2), and a teacher questionnaire (see 3.2.3.3).

3.2.3.1 Classroom observation

The Focus on Four classroom observation schedule (see Appendix H) is designed to collect data on teachers' instructional approaches to teaching the Mathematics concepts, principles and strategies tested in the item tests. The schedule is comprised of two parts:

- Part 1: designed to collect data on the lesson context; and
- Part II: designed to collect data on teachers' instructional practices.

Part 1

Part 1 of the observation schedule provides information on the lesson context such as the number of learners present in the class, the classroom conditions, the teacher's use and organisation of support material; the use of calculators, textbooks and other resources in the lesson, etc.

Part II

Part II of the observation schedule provides information on the teachers' instructional practices. The conceptual categories for this instrument are derived from the SMSO conceptual model for instructional practices. The SMSO model includes:

1. the amount of conceptual coherence or focus the teachers build in their lessons;
2. how teachers represent the subject matter;
3. the patterns of classroom discourse;
4. social organisation in the classroom;
5. participation (who participates);
6. the organisation and nature of the instructional tasks;
7. types of evaluation used;
8. the availability and use of technological and other material resources (IEA TIMSS. 1996b: 5-4 Table 5.2 Factors that influence Instructional Practices).⁶

The seven criteria formulated for use in Part II of the Focus on Four classroom observation instrument are derived from the first seven of the above categories (the eighth criterion is covered in Part 1 of the schedule).

The Focus of Four criteria formulated to collect data on the Grade 4 Mathematics teachers' instructional strategies are:

1. Does the teacher explain the Mathematics concepts, principles and strategies to be learnt?
2. Does the teacher demonstrate how the Mathematics concepts, principles and strategies to be learnt work?

⁶ The model represents a psycho-social view of classroom practice compatible with contemporary cognitive-psychology literature, and influenced by constructivist education literature in the U.S. (Schmidt et al, 1996: 17)

3. Does the teacher engage learners in discourse about the Mathematics concepts, principles and strategies to be learnt?
4. Does the teacher organise learner-learner discussion about the Mathematics concepts, principles and strategies to be learnt?
5. Does the teacher provide learners with opportunities to participate in practising using the Mathematics concepts, principles and strategies to be learnt?
6. Does the teacher structure Mathematics activities through which learners experiment with using the Mathematics concepts, principles and strategies to be learnt?
7. Does the teacher assess whether learners have learnt the Mathematics concepts, principles and strategies?

The seven criteria cover three main aspects of teachers' instructional practices:

- classroom interactions (criteria 1, 2, 3 and 4),
- activities learners do in their Mathematics lessons (criteria 5 and 6); and
- teachers' approach to assessment (criteria 7).

The criteria are based on the assumption that certain teaching practices are likely to be typical of most Mathematics lessons (although not all of the practices are likely to be given equal emphasis in all lessons). The assumption was that the practices identified would be recognisable through observation of one or two of each of the sample teacher's Mathematics lessons and would not require ongoing monitoring.

The seven criteria served to make explicit the practices that fieldworkers were to focus their attention on during the lesson observed. In this way the collection of comparable data across all twelve teachers' lessons was made possible. Furthermore, fieldworkers did not need to rely on teacher self-report through in-depth interviews with teachers.

In order to ensure that important variations in teachers' practices in terms of each of the seven criterion could be captured, the researchers formulated five indicators for each criterion. Each indicator has been formulated and organised on the observation instruments in a way that allows for significant qualitative differences and/or similarities in teacher's instructional practices in terms of the particular criterion to be categorised and recorded across a graded continuum.

For example, the following five indicators have been formulated to collect information on qualitative differences or similarities in teachers' approaches to demonstrating how the Mathematics concepts, principles and strategies work:

1. Teacher does not demonstrate how the Mathematics concepts, principles or strategies work.
2. Teacher uses unfamiliar, indirect Mathematical imagery, abstractions or representations to demonstrate how the Mathematics concepts, principles or strategies work.

3. Teacher uses concrete or physical representations or examples from learners' real-life experiences e.g. counters, sketches, pictures, money, number lines, analogies etc. to demonstrate how new/unfamiliar Mathematics concepts, principles or strategies work. Teacher focuses learners' attention on the actual representations or real-life experiences, or on the Math concepts, principles or strategies rather than on the relationship between the representations and the Math concepts, principles or strategies.
4. Teacher uses multiple representations including concrete or physical representations and indirect Mathematical representations or examples from learners' real life experiences to demonstrate how new/unfamiliar Mathematics concepts, principles or strategies work. Teacher focuses learners' attention on the relationship between new Mathematics concepts, principles or strategies and the representations or real-life experiences. Teacher does not demonstrate how the new Math concepts, principles or strategies are generalised and applied to solve problems of a homologous Mathematical form.
5. Teacher uses multiple representations including concrete or physical representations including concrete and physical representations and indirect Mathematical representations or examples from learners' real life experiences to demonstrate how new Mathematics concepts, principles or strategies work. Teacher focuses learners' attention on the relationship between new Mathematics concepts, principles or strategies and the representations or real-life experiences. Teacher demonstrates how the new Mathematics concepts, principles or strategies are generalised and applied to solve problems of a homologous Mathematical form. For example, by restating familiar problems in more general and widely applicable terms through the use of the Mathematics concepts, principles or strategies (i.e. indirect Mathematical imagery, abstractions or representations).

The description of each indicator has been formulated as unambiguously as possible so that:

- ✍ the various indicators are not open to a variety of interpretations,
- ✍ appropriate and consistent reports on teachers' classroom practices can be made by different fieldworkers;
- ✍ comparison of specific data across the twelve teachers' lessons is possible.

Furthermore, in order to ensure that the data collected is quantifiable and thus amenable to statistical analysis, each indicator for each criterion on the instruments was given a rating or score. This makes it possible to summarise each teacher's practices in terms of each of the criterion in a score, and in terms of an overall score for all the criteria combined.

The quantitative and qualitative aspects of the observation instrument are designed to allow for qualitative differences or similarities in teachers' practices in terms of each of the criterion to be related to differences and/or similarities in learner attainment in each of the Grade 4 Mathematics classes.

Two additional aspects of the design of part II of the classroom observation instruments are the inclusion of two sections that allow fieldworkers to report on

- a) the extent to which learners were interested and involved; and
 - b) the language/s most used in lessons
- in terms of each of the criterion

Thus fieldworkers were also able to indicate the estimated percentage (100%, 75%, 50%, 25%, 0%) of learners who appeared:

- extremely unable, unable, able or very able to engage in terms of criteria 3, 4, 5 and 6; and
- extremely uninterested / inattentive, uninterested / inattentive, interested / attentive or very interested / attentive in terms of criteria 1,2 and 7.

Fieldworkers were able to indicate which language/s (English/Xhosa) were most used by teachers and learners and for the activities in the lessons observed.

The two research co-ordinators used the classroom observation instruments to observe each teachers' Mathematics lessons through at least one classroom visit during the first term. Teachers were informed of the proposed dates of these visits (although in some cases teachers said they had forgotten about the arrangement on the day). Video recordings and short units of translations of transcripts from the video recordings were made of each of the lessons. The recordings and transcripts were used for more in-depth analysis of classroom interactions, tasks and forms of assessment.

The primary purpose of the observation schedules was to assess the level at which teachers were able to engage learners with Math concepts and processes in terms of the criteria. Secondary purposes of the schedules were to capture and describe

- a) 'outward forms' of teachers' teaching strategies such as the types of classroom organisation used by the teachers; and
- b) the level of learner participation in the lessons. For example, whole class teaching even when it involved occasional 'chanting' by learners, was rated as more effective than unstructured/unmediated group investigations.

3.2.3.2 Teacher interviews

After each lesson observation each teacher was asked to respond to a structured interview (see Appendix J). The interview questions on the interview schedule helped to establish details about the lesson context. In particular, the interview included questions about aspects of the lesson that would not necessarily be evident through classroom observations and that could only be obtained directly from the teacher. For example, teachers were asked whether the lesson was an introductory lesson; a continuation lesson, or the end of a series of lessons; the purpose/goal of

the lesson; the Mathematics topics or content the teacher intended covering in the lesson, adverse factors affecting the school or learners on the day; the textbooks and other curriculum documents used in planning the lesson; criteria used for grouping learners, and information about other issues such as the availability of calculators.⁷

3.2.3.3 Teacher questionnaire

In addition to the classroom observation and teacher interview schedules, instrumentation for gathering data on the implemented curriculum included a teacher questionnaire (see Appendix L) administered to teachers at the end of the first term. This teacher questionnaire was linked to the questionnaire administered to teachers in the initial survey of the intended curriculum at the end of 1997 or at the beginning of the first term of 1998 (see Appendix B). The purpose of the (end of term) questionnaire was to identify the extent to which the intended curricular topics/subtopics had actually been addressed during the first term. Teachers were asked to indicate whether the following topics/subtopics had been covered and to provide an indication of the estimated number of lessons in which the topics/subtopics had been covered:

- a) Whole numbers
 1. Place value and numeration
 2. Whole number meanings
 3. Basic operations - addition; subtraction; multiplication; division
- b) Estimation and number sense
- c) Problem solving strategies

The researchers were able to use data from the teacher questionnaire to link the intended curriculum to the implemented curriculum.

3.2.4 The attained curriculum

The attained curriculum was studied through learners':

- achievement in TIMSS items tests that reflect the intended curriculum; and
- aspirations and attitudes towards Mathematics as reflected in their responses in the questionnaire.

3.2.4.1 Selection of TIMSS achievement items which reflect the intended curriculum

The TIMSS included a total of 102 written Mathematics test items for the learner population that forms the subjects of the Focus on Four study. Sixty-five of the Mathematics items have been released for general use by researchers. The Focus on Four researchers decided to select items from

⁷ The researchers acknowledge that teachers' beliefs and theories about teaching and learning are closely linked to their classroom practices. Nevertheless, the aim of the Focus on Four study was to investigate effective classroom practices through an examination of the relationship between teachers' classroom practices and learners' Mathematical achievement and interest in Mathematics. Thus no attempt has been made to use the teacher interviews to establish details about teachers' beliefs or theories about teaching and learning, or to establish links between teachers' beliefs and theories and their classroom practices in terms of each of the criterion.

the group that are available for general use (see Appendix K). Two criteria were used to select the items used in the study:

- the item topic (content) and type; and
- the difficulty level of the item in terms of cognitive complexity. Item topic and type

Items had to match the topics (content) that the sample of teachers indicated that they intended to teach in the first term of 1998 (see Section 4 of this report). Twenty five of the available written TIMSS items were selected as matching the intended curriculum. Seven of these items (28%) are in the free-response format (where learners are required to produce and write their own answers). Five of these free-response items require short answers, while 2 require extended responses involving multiple steps or synthesis of information where learners show their work. The other 18 items (72%) use a multiple-choice format where learners have 4/5 choices, of which only one is the best or correct answer.

Table 3 below illustrates the distribution of the 25 TIMSS test items selected for Focus on Four across content (topic) areas and performance expectations (see 2.1.1) and item type. Each of the item tests selected is coded with one content category and one performance expectation category.

TABLE 3: DISTRIBUTION OF TIMSS ITEM TESTS SELECTED FOR FOCUS ON FOUR ACROSS CONTENT (TOPIC) AREAS AND PERFORMANCE EXPECTATIONS, AND ITEM TYPE

CONTENT CATEGORY	Number of Items	Number of Multiple Choice Items	Number of Short-Answer Items	Number of Extended Response Items
Whole Numbers	17	10	5	1
Patterns, relations and functions	6	6	-	-
Estimation	1	1	-	-
Probability	1	1	-	-

PERFORMANCE EXPECTATIONS	Number of Items	Number of Multiple Choice Items	Number of Short-Answer Items	Number of Extended Response Items
Knowing	5	4	1	-
Using Complex Procedures	4	4	-	-
Solving Problems	9	5	2	2
Performing Routine Procedures	7	5	2	-

Adapted from TIMSS Mathematics Items Released Set for Population 1 (Third and Fourth Grade) page iv.

The percentage of test items devoted to each of the topic areas are:

- whole number 68%;
- patterns, relations and functions 24%;

- estimation 4%; and
- probability 4%.

The main content category 'whole numbers' includes understanding place value up to the thousands, ordering and comparing numbers and solving single as well as multi-step problems involving operations of addition, subtracting and multiplication. One test item involves rounding and estimation, and one assesses the area of probability. Six items involve patterns of numbers and shapes, representations of simple numerical situations, and relationships between sequences of numbers.

The percentage of test items devoted to performance expectations are:

- knowing 20%,
- using complex procedures 16%;
- solving problems 36%; and
- performing routine procedures 28%

The difficulty level of the item in terms of cognitive complexity

In addition to selecting items which represented the topics to be taught, Focus on Four researchers also took into account the different levels of difficulty in terms of cognitive complexity of each of the items selected. Each of TIMSS items is coded according to an International Difficulty Index or an international measure of item difficulty. In addition, the international average percentage of learners who responded correctly to each item in the 2 adjacent (upper and lower) grades tested is provided for each item test.

Table 4 below illustrates the distribution of the 25 TIMSS test items selected for Focus on Four in terms of TIMSS International Difficulty Index and in terms of the international average percentage of learners who responded correctly to the item in the two adjacent grades.

TABLE 4: ITEM TESTS: INTERNATIONAL DIFFICULTY INDEX AND INTERNATIONAL AVERAGE PERCENTAGE OF LEARNERS WHO RESPONDED CORRECTLY TO THE ITEMS

Item Number	International Average Percentage of Learners Responding Correctly		International Difficulty Index
	Upper Grade	Lower Grade	
I-3	57%	46%	547
I-4	84%	74%	400
I-7	62%	49%	545
I-9	71%	50%	513
J-4	45%	30%	614
J-5	39%	27%	627
J-8	52%	33%	591
J-9	73%	64%	460
K-2	84%	67%	429
K-3	53%	37%	589
K-6	63%	52%	530
L-2	51%	40%	585
L-4	72%	61%	488
L-7	49%	33%	607
M-3	63%	53%	524
M-6	70%	57%	493
M-8	86%	76%	381
M-9	70%	55%	493
S-2	63%	44%	530
T-2	43%	29%	614
V-2	48%	30%	603
U-5	77%	63%	418
V-3	62%	48%	519
V-4a	24%	16%	698
V-4b	48%	31%	590

Table 5 provides a summary of the total number of the selected items for which:

- less than 50% of the international average percentage of learners in the upper/lower grade responded correctly;
- 50% or more of the international average percentage of learners in the upper/lower grade responded correctly.

The table also provides the number of items coded as less than 500, and 500 or more in terms of the International Difficulty Index.

TABLE 5: TOTAL NUMBER OF ITEMS SELECTED IN TERMS OF THE INTERNATIONAL DIFFICULTY INDEX AND THE INTERNATIONAL AVERAGE PERCENTAGE OF LEARNERS WHO RESPONDED CORRECTLY

Upper grade		Lower grade		International Difficulty Index	
less than 50%	50% or more	less than 50%	50% or more	less than 500	500 or more
7	18	14	11	8	17

3.2.4.2 Attitudes as outcomes or perspectives aspect

A learner questionnaire designed to ascertain details about learner backgrounds and changes to learner attitudes and aspirations in terms of Mathematics was adapted from TIMSS (see Appendix G).

Included in the learner questionnaire are subsets of questions designed to establish:

- learners' attitudes towards Mathematics;
- their perceptions about the value of Mathematics;
- how they perceive their own success in Mathematics;
- their beliefs about the abilities necessary to succeed in Mathematics.

For example, learners are asked whether they think it is important to

- do well in Maths at school?
- be good at sports?
- have time to have fun?

The adapted learner questionnaire was translated into Xhosa and tested in a field test using similar Grade 4 learners to those that were to be used in the study.

In the original TIMMS questionnaire, learners were asked to respond to such questions/statements by indicating whether they 'strongly disagree', 'disagree', 'agree', or 'strongly agree'. However, the field test revealed that these choices were too complex for most learners at the Grade 4 level. Thus some questions had to be modified so that learners could indicate responses of 'yes' or 'no', or 'agree' and 'disagree'.

The modified learner questionnaire was administered to the sample of learners at the beginning of the first term. Fieldworkers read and explained each question to the learners in Xhosa. At the end of the first term learners were asked to complete a second questionnaire (see Appendix M) consisting of a subset of five questions, numbers 11, 12, 14, 15 and 17, repeated from the first questionnaire. The fieldworkers read and explained the questions to the learners in Xhosa. Learners' responses to these questions were used to see if surface changes in their attitudes and aspirations in terms of Mathematics could be established.

Because of the modifications to the questionnaires made as a result of the findings in the field test, it was not possible to identify significant or valid variations in changes in learners' attitudes and aspirations. Nevertheless, the results of these five questions from the questionnaires have been used to identify links between learner interest in and attitude towards Mathematics, and teachers' instructional practices.

3.2.4.3 Data collection quality control for the item tests Preparation for data collection

The Focus on Four fieldworkers received training at a one day orientation course on 10 December 1997. A second orientation was held prior to administering the post-tests on 16 March 1998. Training included:

- an introduction to Focus on Four, its background, aims, purpose and rationale;
- the influence of TIMSS;
- an overview of the fieldworkers' roles, responsibilities and tasks;
- instructions for translations of tests and learner questionnaires;
- instructions for schools visits and administering the item tests and learner questionnaire;
- instructions on returning the tests to Focus on Four

Training sessions on recording the test results was held in February 1998 after the pre-tests had been administered and in March after the post-tests had been administered.

Monitoring the quality of the translations of the item tests and learner questionnaires into Xhosa

In December 1997, a translator was contracted to translate the item tests and learner questionnaires into Xhosa.

The translator is fluent in English and Xhosa. His primary language is Xhosa, and he has a good knowledge of primary school Mathematics and of the culture and reading level of the Grade 4 learners selected for the study. His brief, which was adapted from TIMSS guidelines for producing translations, was to

- adapt the items/questions to local conditions by minimising cultural differences (for example by changing any names which would be unfamiliar to the learners);
- find equivalent words and phrases to those used in the original text,
- ensure that the reading level of the text remained the same in the Xhosa version as in the English version;
- ensure that the essential meaning and difficulty of the test items did not change; and
- ensure that questions were translated in ways that prevented the likelihood of another possible correct answer for items.

In addition to translating the items and questionnaire, the translator was able to organise for a second translation to be made. The two versions were compared to establish whether the translations were the same for most items. Where the versions differed, differences were discussed and

the best version was selected. The final version was then reviewed by the second fieldworker.

As the languages of instruction in the Grade 4 Mathematics classes at all the schools in the sample are English and Xhosa, the Focus on Four researchers decided to include the English and Xhosa translations on each page of the item tests. The English translation precedes the Xhosa translation on the test page. These changes have not affected the format or layout of the tests significantly.

The fieldworkers tested the translated and re-formatted items and the learner questionnaire in a field test in the first week of the term in 1998 (the versions of the tests with the Xhosa translations were only ready by the middle of December when the schools had closed). The field test was conducted using Grade 4 learners from a school site similar to the schools that were used in the study. Learners' results in the field tests were low. However, as TIMSS tests represented Mathematical knowledge and processes that were externally validated as representing an appropriate standard at the Grade 4 level, and, in the absence of alternative valid tests, the researchers decided to use the tests with some adjustment in terms of testing time (see section headed testing time for details).

Thus verification procedures for the translations include

- comparison with another version of the translations;
- verification by the second fieldworker; and
- testing the translated items and questionnaires in a field test (see also section headed testing time below).

Throughout the translation process the Focus on Four researchers stressed that it was imperative that the item tests remain confidential. In particular the researchers stressed that schools must not have access to the tests as this would contaminate the data.

Data collection procedures for test items

Uniformity of test administration so that comparable data on learner attainment was collected at each site was crucial. The following standardised data collection procedures for administering the learner tests were adopted (see Appendix I):

The fieldworker was to:

- establish the names of learners in the class who were absent on the day of the tests;
- ensure that copying did not occur. For example, by asking learners to sit as far away from one another as is possible or, if this is not possible to put their suitcases or bookbags between them on the desks;
- not give teachers copies of the tests and ask them not to stay in the class while the learners were being tested;
- provide each learner in the classes with a pencil supplied by Focus on Four,

- explain to the learners that they should not talk to each other or look at their classmates work. They should not use calculators, rulers or erasers (they can cross out errors) (Fieldworkers used the learners' primary language to explain this);
- hand out the tests one at a time and tell the learners to complete the details on the cover sheet but not open the test booklets until they are told to do so,
- use the examples provided to explain to learners what is meant by multiple choice questions and how they were different from short-answer questions;
- explain to the learners that the test questions were written in English as well as Xhosa,
- tell the learners that they should do all their calculations on the actual test pages;
- tell the learners how much time they have for the test items;
- encourage the learners to do the best they can but not help them in any way through giving them guidance of any sort,
- not include learners who arrive after the testing has begun, but allow them do the test;
- take in the test booklets if learners have to leave the room during the test (e.g. to go to the toilet), and indicate this on the front cover of the particular booklet;
- check that the number of completed test booklets tallied with the number of learners in the class before they left the testing room;
- ensure that all item test booklets including blank booklets were secured.

In addition, fieldworkers were required to complete a fieldworker questionnaire (adapted from TIMSS) after each testing session (see Appendix F). The questionnaire asked them to provide background information on data collection procedures for each testing session. Included in the questionnaire was information about events outside the study's control which may have affected testing. Thus the questionnaire includes questions about adverse factors or events affecting the school or learners on the day of the testing, whether there was adequate seating space for learners to work on the tests without distractions; whether any deviations from the prescribed timing had to made, etc.

Testing time

The TIMSS provides the following estimates of the amount of time needed by the population of learners used in the study to complete each item type:

TABLE 6: TIME NEEDED TO COMPLETE EACH ITEM TYPE (TIMSS)

Multiple choice	Short-answer	Extended – response
1 minute	1 minute	3 minutes

Of the 25 items selected for the Focus on Four study, 18 are multiple choice items, 5 require short-answers, and 1 item (which consists of a part

A & B) requires an extended-response. Thus, according to TIMSS, the estimated total time allocated for the item tests selected was 26 minutes. In order to establish the amount of time needed for the particular population of learners used in the study to at least attempt each item type, the instruments were tested in a field test with a class of similar Grade 4 subjects. The field test revealed that adjustments to the time allocated for the items needed to be made as learners experienced difficulty with the unfamiliar format of the item tests and, in some cases, lacked the reading skills necessary to read the questions quickly. The researchers decided to allocate 45 minutes for the test so as to ensure that all learners would have the opportunity to at least attempt each question.

The timing of the tests

Most of the schools were provided with a provisional timetable of the testing times at the end of 1997. The exact dates of the pre-test administration were confirmed once schools re-opened in January 1998. The necessary logistical arrangements were made with individual schools during the first week of the first term in 1998.

The post-tests were administered at the end of the second term, between March 18 and March 27, as planned.

Scoring of test items

The test items used for the Focus on Four study include multiple-choice and free-response formats. Learners score one point for each correct answer in the multiple choice items. Multiple choice items are useful in that statistics derived from the items can be used to identify those aspects of teaching that are weak. Furthermore, incorrect choices by the majority of learners can be used to estimate the extent to which learners hold particular misconceptions. However, although multiple choice test items provide information on content and process outcomes, they provide little information about the procedures learners use to solve Mathematical problems. The free-response items are intended to reflect some of these procedures and some of the learners' thought processes.

Unlike the multiple-choice items, TIMSS free-response items (short-answers and extended-responses) are scored using a two digit coding rubric. The two digit score provides both a score for the 'correctness' of the response and an indication of the nature of the response through a qualitative diagnosis of different responses having the same scores. Coding rubrics measure three aspects of responses. These are:

- 'correctness' (correct, partly correct, or incorrect);
- method or type of explanation or example given; and
- misconception or error type.

The first digit of TIMSS two-digit code represents the 'correctness' of the response. The second digit in the code represents the nature of the response in terms of the type of explanation or type of error (for example, strategy used, specific common errors, common misconceptions, or a

learners use of a particular example pertinent to a question) (ref. IEA's TIMSS Two-Digit Coding Scheme, 1996b: 7-13).

Table 7 provides a generic example of the coding scheme for a freeresponse item worth one score point

TABLE 7: FREE-RESPONSE ITEMS - CODING SCHEME

Code	Text
10	correct response, answer category/method #1
11	correct response, answer category/method # 2
12	correct response,, answer category/method # 3
19	correct response, some other method used
70	incorrect response, common misconceptions/error #1
71	incorrect response, common misconceptions/error #2
76	incorrect response, information in stem repeated
79	incorrect response, some other error made
90	crossed out/erased, illegible, or impossible to interpret
99	Blank

(From Table 7.2 IEA's TIMSS Two-Digit Coding Scheme, 1996b, 7- 77)

Responses coded 10, 11, 12 or 19 are correct and each score one point. Responses coded 70, 71, 76 or 79 are incorrect and score no points. Responses coded 90 and 99 allow for differentiation between items where learners have attempted the test but have not provided an answer, and items where learners have not made any attempt. These responses also score no points.

It was hoped that TIMSS coding rubrics would enable the Focus on Four researchers to analyse learners' responses in ways that would provide information about the procedures used by the sample of Grade 4 learners to solve Mathematical problems.

4. STUDYING THE INTENDED CURRICULUM

The intended curriculum is comprised of the learning goals specified at the national or regional level, the school level, and the classroom level.

4.1 Description of the intended curriculum

The description of the intended curriculum includes information on

- official national or regional curriculum documents which each of the participating teachers intended using to guide the Grade 4 Mathematics programme in 1998 (see 4.1.1);
- curriculum topics or content areas the sample of teachers intended covering in the first term of 1998 (see 4.1.2);
- textbooks and other curricular material teachers intended using for their Grade 4 Mathematics teaching (see 4.1.3);

4.1.1 Curriculum documents used by teachers to guide the Grade 4 Mathematics programme in 1998

None of the Grade 4 teachers indicated that they intended using Curriculum 2005 to guide their Mathematics programme in 1998.

All 12 of the sample teachers intended using the provincial Interim Syllabus for the Western Cape (1996) to guide their Grade 4 Mathematics programme in 1998. Teacher 1 reported that she intended using Departmental curriculum guides to guide her programme.

4.1.2 Curriculum topics or areas chosen by the sample teachers for the first term

Table 8 indicates the topics and subtopics the teachers intended covering in their Grade 4 Mathematics lessons in the first term of 1998 as well as the estimated number of lessons in which teachers anticipated that they would be covered.

TABLE 8: TOPICS AND SUBTOPICS TEACHERS INTENDED COVERING IN THE FIRST TERM 1998 AND THE ESTIMATED NUMBER OF LESSONS IN WHICH TOPICS AND SUBTOPICS WOULD BE COVERED

Teacher	Place value & Numeration	No. of lessons	Whole number meaning	No. of lessons	Basic operations - Addition	No. of lessons	Basic operations - Subtraction	No. of lessons	Basic Operations - Multiplication	No. of lessons	Teacher	Basic operations - Division	No. of lessons	Estimation and number sense	No. of lessons	Problem-solving strategies	No. of lessons
1	Yes	5	Yes	5	Yes	4	Yes	4	Yes	3	1	Yes	3	Yes	4	Yes	6
2	Yes	3	Yes	3	Yes	3	Yes	3	Yes	6	2	Yes	6	Yes	6	Yes	6
3	Yes	3	Yes	3	Yes	4	Yes	4	Yes	4	3	Yes	3	Yes	3	Yes	4
4	Yes	6	Yes	6	Yes	4	Yes	4	Yes	4	4	Yes	4	Yes	6	Yes	6
5	Yes	3	Yes	3	Yes	4	Yes	4	Yes	6	5	Yes	5	Yes	4	Yes	6
6	Yes	4	Yes	4	Yes	4	Yes	4	Yes	6	6	Yes	6	Yes	3	Yes	4
7	Yes	4	Yes	4	Yes	5	Yes	5	Yes	4	7	Yes	4	Yes	4	Yes	3
8	Yes	3	Yes	3	Yes	4	Yes	4	Yes	5	8	Yes	5	Yes	4	Yes	4
9	Yes	6	Yes	6	Yes	4	Yes	4	Yes	5	9	Yes	5	Yes	6	Yes	6
10	Yes	6	Yes	6	Yes	4	Yes	4	Yes	5	10	Yes	5	Yes	6	Yes	6
11	Yes	6	Yes	6	Yes	5	Yes	5	Yes	5	11	Yes	5	Yes	3	Yes	6
12	Yes	6	Yes	6	Yes	3	Yes	3	Yes	6	12	Yes	6	Yes	4	Yes	4

Code for estimated number of lessons:

- 3 = 1-5 lessons
- 4 = 6-10 lessons
- 5 = 11-15 lessons
- 6 = > 15 lessons

*From
colle*

The comparison of TIMSS Curriculum Framework for Mathematics; Curriculum 2005; and the Western Cape Interim Syllabus revealed that:

- essential elements of TIMSS curriculum framework were included in Curriculum 2005 and the Western Cape Interim Syllabus;
- while the content and performance expectation categories in TIMSS framework were discrete, in Curriculum 2005 and the Western Cape Interim Syllabus of these categories were collapsed;
- TIMSS framework, by virtue of its required applicability across 26 countries was devoid of non-mathematical (i.e. political and methodological) direction. The content and performance expectations were explicit and teaching methodology existed as a vehicle rather than as an outcome;
- while attitudes and values were given attention in TIMSS framework, this was not taken to be the central focus; and
- there were significant distractors in the Interim Syllabus and Curriculum 2005 that might subvert teachers' practice. For example, statements that learners should only be taught when they were ready, etc.

4.3 Summary

The study of the intended curriculum revealed that

- all twelve teachers intended using the provincial Interim Syllabus for the Western Cape (1996) to guide their Grade 4 Maths program;
- all the teachers held a common intended curriculum. They all intended covering the same topics/subtopics;
- all twelve teachers reported that they intended using textbooks in the Mathematics teaching in 1998; and
- there was considerable variation in the textbooks that the teachers intended using for their Grade 4 Maths teaching.

5. STUDYING THE SOCIAL AND EDUCATIONAL CONTEXTS OF LEARNING

The conceptual framework of learners' "opportunity to learn" in TIMSS includes a number of integrated contextual variables or factors that might contribute to differences in teacher effectiveness and learner achievement.

Section 5 of this report provides information on some of the societal (see 5.1) and educational contexts (see 5.2) of learning and teaching in terms of the samples of learners and the sites used for the Focus on Four study.

5.1 Societal context

The societal context in which the schools operate is described in terms of local community characteristics (see 5.1.1) and learners' backgrounds and home environment (see 5.1.2).

5.1.1 Local community characteristics

Principals at all nine schools reported that some, most or all their learners came from poverty-stricken backgrounds; came from homes where their parents/ main caregivers did not receive more than primary schooling, came from homes that do not have electricity; and have health or nutrition problems.

School location

All nine of the schools used in study were situated in townships / settlements near Cape Town. Eight of the nine schools used in the study were located in the Nyanga / Crossroads area. The ninth school was located in Langa.

Primary language(s) of learners at home

Principals' of all nine schools reported that the primary language of the majority of learners at home was Xhosa.

Principals' reports on the primary language(s) of minority groups of learners indicated that there were minority groups of learners who spoke languages other than Xhosa (South Sotho, Setswana or Afrikaans) at home at four of the sample schools (Schools 4,7,8 and 9).

5.1.2 Learners' backgrounds and home environments

58% of the learners' reported that they never spoke English at home. 28% reported that they sometimes spoke English at home.

90% of the learners reported that their parents/caregivers thought it important for them do well in Maths at school. 72% reported that their parents/caregivers thought it important for them to be good at sports. 83% reported that their parent/caregivers thought it important for them to have time to have fun.

47% of learners reported that 6 or less people lived in their homes.

53% of the sample of learners reported that they had fewer than 26 books in their homes.

77% of the sample of learners reported that they did not have computers in their homes.

75% of the learners reported that they had calculators at home. 71% of the learners reported that they had a table or study desk at home. 57% of the learners reported that they had a dictionary at home.

97% of learners reported that they think it is important to do well in Maths at school. 86% of learners reported that they think it is important to be good at sports. 91 % reported that they think having time to have fun is important.

Peer influence

85% of learners reported that their friends think it is important to do well in Maths at school. 78% of learners reported that their friends think it is important to be good at sports. 83% reported that their friends think having time to have fun is important.

5.2 Educational contexts

The educational context is described in terms of school (see 5.2.1), teacher (see 5.2.2) and classroom characteristics (see 5.2.3), and learners' experience of the educational context (see 5.2.4).

5.2.1 School characteristics

The nine schools used in the study are all former DET schools.

None of the principals reported having double shift/platoon systems at their schools.

The most common factors that principals of the sample of schools cited as influencing or determining learner admission to the schools were - residence in a particular area, preference given to learners whose primary language is the same as the majority of learners at the school, and the recommendation of previous teachers.

Principals' reports on the behaviour of the Grade 4 learners at the schools indicated that the most common problems at the schools were learners arriving at school late and absenteeism. The least common problems were intimidation or verbal abuse of staff, and physical threats or injuries to staff.

According to principals' reports on the total enrolment at each school, six of the schools had an enrolment of more than one thousand learners. Three schools had enrolments of less than one thousand learners. School 3 had the largest enrolment of the twelve schools (1670 learners). School 9 had the smallest enrolment of the twelve schools (790 learners). The average school enrolment was one thousand one hundred and five.

Principals' reports indicated that absentee rates at the schools ranged from 1 - 8% of all learners on a typical school day. Four schools reported that 1 - 2% of learners were absent in the whole school on a typical school day. Four schools reported that 3 - 5% of learners were absent on a typical school day. One school (school 6) reported that 8% of learners were absent on a typical school day.

Principals' reports on the number of full-time staff at the schools and learner enrolment indicated that the teacher:learner ratio at the schools ranged from 27:1 (School 6) to 56:1 (School 3). The data indicated that the ratio at five of the schools was between 30-40:1. Data indicated that two of the twelve schools had a ratio of less than 30:1 and that two schools had a ratio of more than 40:1.

Six of the school principals reported that they had been principal at their schools for 5 or more years. One principal reported that he/she had been principal for 3-4 years. Two principals reported that they had been principals at their schools for 1-2 years.

Principals at all the schools indicated that they regarded shortages or inadequacies of budgets for supplies; computers, calculators, and computer software for Maths instruction; instructional space; library materials and audio visual materials relevant to Maths instruction as the issues that most commonly affected their schools' capacity to provide Maths instruction.

Four of the principals reported that there were no computers available at their schools. Principals who reported that their schools had computers reported that they were used by office staff for record keeping, or by teachers for administrative purposes. Only one school, School 1, reported having a computer available for general use by learners. None of the schools had computers available for use by the teachers/learners for educational purposes.

Institutional arrangements at the school

Principals' reports on who had primary responsibility for school activities revealed that teachers at the schools were mainly responsible for establishing assessment and learner grading policies; placing learners in classes; deciding what textbooks to use; establishing homework policies; and determining subject content. Principals were mainly responsible for assigning teachers to classes and establishing community relations. School governing bodies together with principals were mainly responsible for establishing disciplinary policies at the schools.

Six principals reported that Grade 4 teachers collectively were responsible for setting the Grade 4 Maths examinations. Three principals reported that individual Grade 4 Maths teachers were responsible for setting Grade 4 Maths examinations.

Principals at all nine schools report that the schools had an official policy related to promoting co-operation and collaboration among teachers; that teachers were encourage to share and discuss instructional ideas and materials; and that teachers met regularly to discuss instructional goals and issues.

According to principals' reports the total number of Grade 4 learners at the schools ranged from 80 (at School 4) to 181 (at School 7).

Principals at six of the schools reported that there were three Grade 4 classes at their schools. Principals at two schools reported that there were four Grade 4 classes at their schools. The principal of the ninth school reported that there were two Grade 4 classes.

Principals' reports on the number of instructional hours in the average school week (excluding breaks, assemblies etc.) indicated that the number of hours ranged from 28 hours (at school 5) to 23 hours (at school 8). Three of the remaining nine schools had 27 hours of instruction per week, one school had 26 hours, and three schools had 25 instructional hours in the average school week.

Principals' reports on the number of minutes in a typical instructional period indicated that eight of the nine schools had 30 minute periods. School 7 had 45 minute periods.

5.2.2 Teacher characteristics

All twelve teachers reported that Xhosa was their primary language.

Eight of the twelve teachers reported that they were between 30-39 years of age. Two teachers reported that they were between 25-29 years of age. One teacher reported that he/she was between 50-59 years of age. One teacher reported that he/she was between 40-49 years of age.

Seven teachers reported that they had taught grade levels higher than Grade 4 in the last 5 years. Five teachers reported that they had taught Grade 4 and lower grades in the last 5 years.

Eight teachers reported that the highest formal level of education they had completed was Matric plus three years teacher training. Two teachers reported having completed Matric plus four or five years teacher training. One teacher reported that she/he had completed a Bachelors degree plus teacher training. Only one teacher reported that she/he had completed Matric plus two year teacher training. In other words only one of the teachers was classified as under-qualified in terms of the COTEP document.

Eight of the twelve teachers reported that their last formal academic/ teaching qualification was achieved in the last five years. Two teachers reported that the year that their last formal academic/teaching qualification was achieved in 1997. One teacher reported that year that his/her last

formal academic / teaching qualification was achieved in 1980 (eighteen years ago).

Half the teachers reported that they were Maths subject specialists.

Eight of the teachers reported that they had attended Maths in-service courses in the last 10 years. Three teachers reported attending in-service courses with more than one in-set provider. Seven teachers reported that they had attended courses with the Maths Education Project, housed at the University of Cape Town. Two of the teachers reported that they had attended courses run by the Primary Maths Project. Two teachers reported attending Departmental courses. One teacher reported attending a course presented by the Thousand Schools Project. One teacher reported attending a Primary Primset course, and another teacher reported that he/she had attended a course run by Master Maths.

Teachers reports on time spent on school activities outside the formal school day during the school week indicated that they spend the most time (1 - 2 hours each) keeping learner records up to date, reading and marking learner work (other than tests and examinations), and doing administrative tasks (including staff meeting). Reports indicated that the activities they spend the least time (less than 1 hour) on were tutoring/given extra lessons to learners outside classroom time, and planning lessons by themselves.

Eleven of the teachers reported that they met with other teachers in their subject area to discuss and plan the Grade 4 Maths curriculum or teaching approaches at least every second month if not more frequently. Teacher 6 reported that she/he never met with other teachers in their subject area.

Nine of the twelve teachers reported that teaching was their first choice of career.

Eight of the twelve teachers reported that they would not change to another career if they had the opportunity. The remaining four teacher reported that they would change if they had the opportunity.

All twelve teachers reported they believed that their learners appreciated their work.

Eleven of the teachers said they believed that society appreciated their work. Only one teacher felt that society did not appreciate his/her work. Teacher 4 reported that she/he had more than 200 books in his/her home. Three teachers reported having between 101 and 200 books in their homes. Four teachers reported having between 26 and 100 books in their homes. Two teachers reported having between 11 and 25 books in their homes. Teacher 9 reported having fewer than 11 books in her/his home.

5.2.3 Classroom characteristics

Teachers' reports revealed that the size of the largest Grade 4 Maths class tested for the study was 54. The size of the smallest class was 35. The average class size was 44.

Data provided by teachers on the dates of birth of the sample of learners indicated that all classes had large age ranges. The sample of learners' ages ranged from eight to eighteen years old. Learners who start school at the age of seven and progress uninterrupted through school should turn ten in Grade 4. Data from the study indicated that 41 % of the sample of learners were above the norm of ten years of age at the time of testing.

Teachers' reports on the average number of minutes of Maths taught weekly to their Grade 4 classes indicated that time spent ranged from 180 minutes (Teacher 6) to 405 minutes (Teacher 11). Three teachers reported that they taught Maths for 300 minutes. Five teachers reported that they taught for 270 minutes, and two teachers reported that they taught their class Maths for 210 minutes.

Teachers' reports on what factors limited how they taught their Grade 4 classes Maths indicated that teachers felt that the three factors that most limited their teaching were learners with different academic abilities, shortages of equipment for use in demonstrations and other exercises; and high learner:teacher ratio. The three factors that teachers felt least limited their teaching were low morale among teachers/school administrators; and uninterested or disruptive learners.

Teachers reported that calculators were used most frequently in their Grade 4 Maths classes for checking answers, solving complex problems and exploring number concepts. They reported that they were used least frequently for tests and exams, and routine computations.

All twelve teachers reported that they gave their Grade 4 learners Maths homework. Eight teachers reported that they gave homework $\frac{3}{4}$ times a week. Two teachers reported that they gave homework every day. Two teachers reported that they gave homework once or twice a week.

Teacher's reports on their use of learners' written Maths homework indicated that teachers most usually corrected, collected and returned homework to learners, and used homework to give feedback to the whole class. The reports indicated that teachers seldom had learners correct their own assignments, or used it as a basis for class discussion.

All teachers reported that they tested their Grade 4 Maths classes. Eight of the teachers reported that learners wrote tests once a month. Four teachers reported that their Grade 4 Maths learners wrote tests once a week.

During lesson observations fieldworkers reported that most classrooms had cupboards/ storage space, usable chalkboards, a table for the

teacher; sufficient seating or desks or writing surface(s) per learner; sufficient space for the teacher to organise different activities or seating; adequate lighting; adequate ventilation; a comfortable temperature; and noise or outside distraction. Conditions in three of the classrooms were not adequate in terms of all of the above criteria. One lesson was disturbed by noise from outside the classroom. One classroom had insufficient seating or desks or writing surface(s) per learner. One classroom had no cupboard/storage space.

The learners' experience in the educational context

65% of learners reported that in the last month at school something of theirs had been stolen. 29% reported that in the last month at school some of their friends had had things stolen. 42% reported that in the last month they had thought another student might hurt them. 54% reported that some of their friends had been hurt by other learners.

5.3 Summary

Data on the social and educational contexts for learning indicates that the sample of schools, teachers and learners form relatively homogenous groups. However, data also reveals key school and classroom variables and/or variables in teacher backgrounds that may be related to teacher effectiveness, or that could contribute to differences in learner achievement (see 8.2). In particular, variables in school characteristics such as the number of minutes allocated to Mathematics teaching per week; teacher characteristics such as teachers' experience, qualifications, and attendance at in-service programs; and variables in classroom characteristics such as learners' age ranges, and class size.

The findings confirm the view that the social and educational context for learning and teaching is an important unit for analysis in planning curriculum reform processes, teacher development programs, and materials development.

6. STUDYING THE IMPLEMENTED CURRICULUM

This section of the report examines the ways in which learners' learning experiences were similar or differed across the twelve classrooms.

Section 6 provides information on the implemented curriculum in terms of the following:

- ✎ extent of coverage of topics/subtopics (see 6.1);
- ✎ reports on teachers' classroom practices in Grade 4 Mathematics classes (see 6.2)', and
- ✎ learner interest and involvement (see 6.3).

6.1 Extent of coverage of topics/subtopics

The extent of teachers' coverage of topics/ subtopics is provided as a background to the descriptions of teachers' practices in the classrooms.

There were 49 teaching days in the first term of 1998. The sample of learners had six weeks of schooling between the pre- and post-tests.

Teachers' reports on the average number of minutes of Maths taught weekly to their Grade 4 classes indicated that time spent ranged from 180 minutes' (Teacher 6) to 405 minutes (Teacher 11). Three teachers reported that they taught Maths for 300 minutes. Five teachers reported that they taught for 270 minutes, and two teachers reported that they taught their class Maths for 210 minutes.

Figure 2 provides the estimated amount of teaching/learning time that the sample of Grade 4 learners in each class received in Maths classes between the pre- and post-tests. (Figures are based on teachers' reports on the number of hours of Maths lessons learners received per week.)

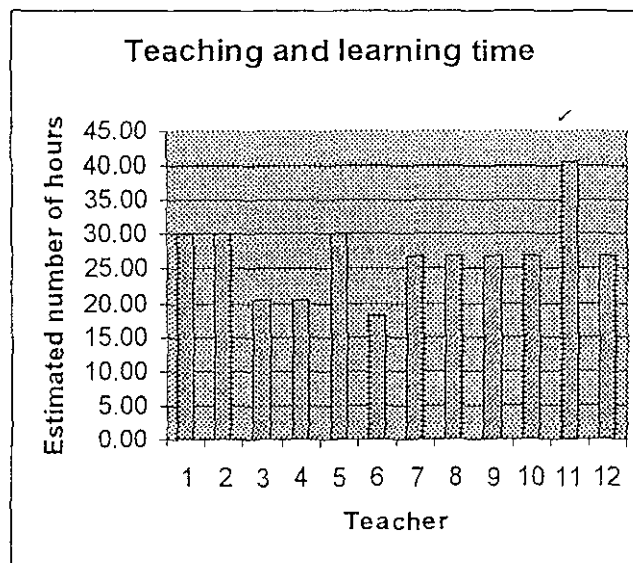


Figure 2

Teachers' reports indicated that the number of hours of Maths teaching in the twelve classes ranged from 18 hours to 40,5 hours.

Figures 3 - 10 summarise teachers' reports on topics/subtopics covered in the first term of 1998 and the estimated number of lessons in which each of the topics/subtopics were covered. The figures provide an indication of the emphasis teachers gave to the different topics/subtopics.

Key - estimated number of lessons
 0 = none
 3 = 1-5 lessons
 4 = 5 -10 lessons
 5 = 11 - 15 lessons
 6 = > 15 lessons

Whole numbers

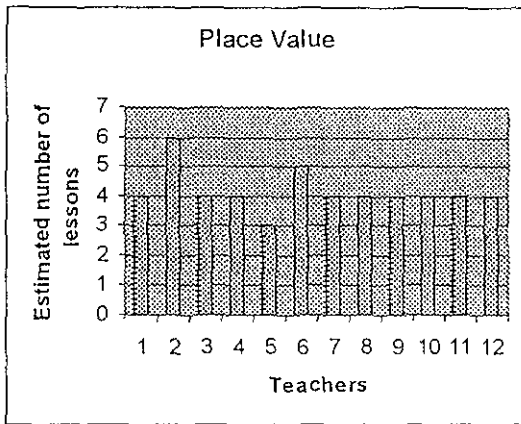


Figure 3

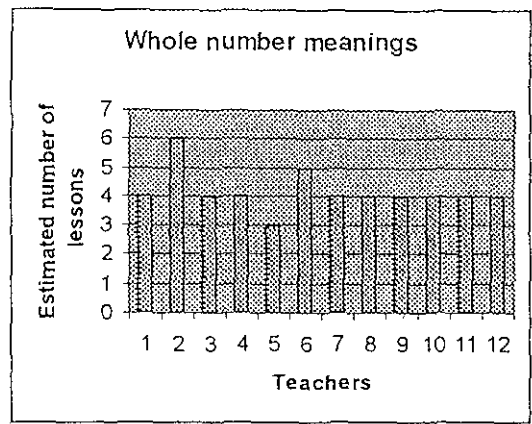


Figure 4

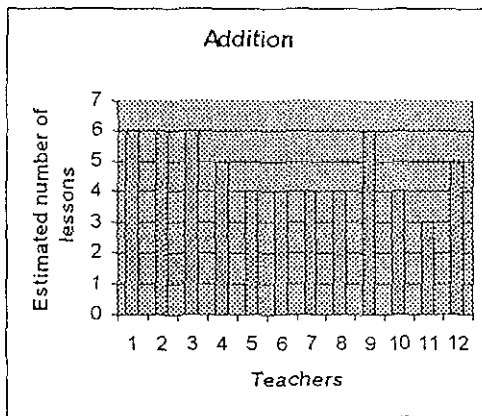


Figure 5

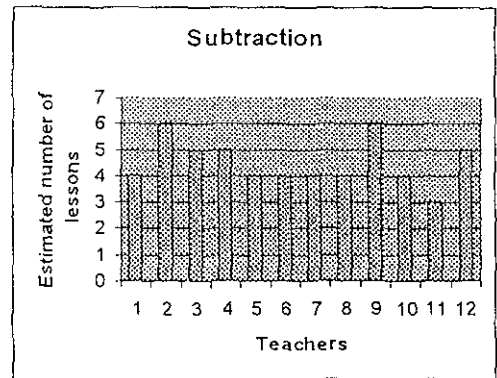


Figure 6

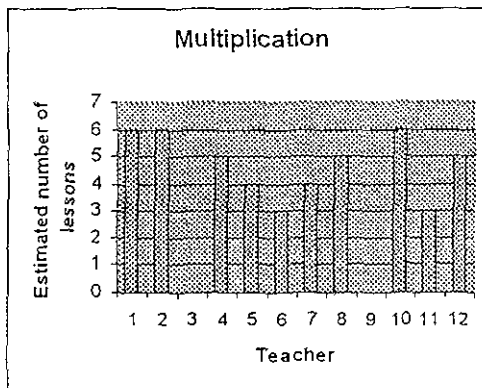


Figure 6

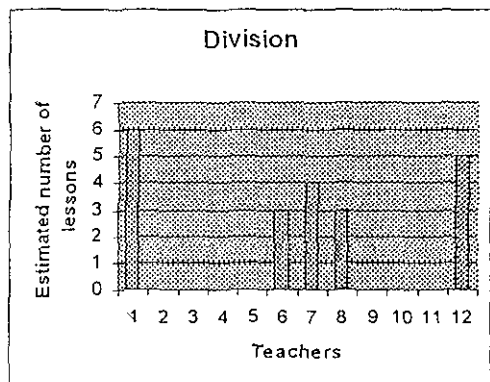


Figure 7

Estimation and Number Sense

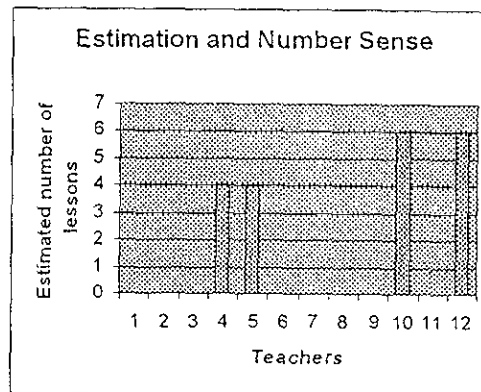


Figure 8

Problem solving strategies

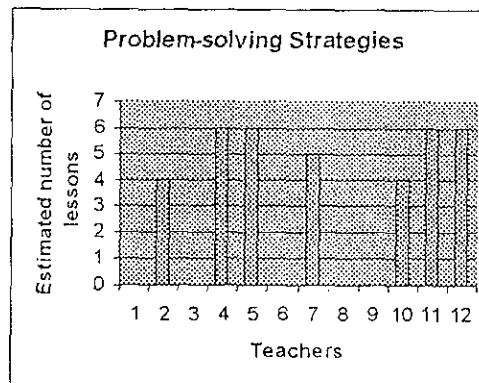


Figure 9

According to teachers' reports the most emphasised topics were 'whole numbers', in particular, the subtopics of the basic operation of 'addition'; 'numeration and place value'; 'whole number meanings', 'subtraction'; and 'multiplication'. The least emphasised topics/subtopics were the more complex operations/procedures of 'division'; 'estimation and number sense'; and 'problem solving strategies'.

Two of the twelve teachers indicated that they had not covered the basic operation of 'multiplication' in the first term. Seven of the teachers' reports indicated that they had not covered the basic operation of 'division' in the first term. Eight of the teachers' reports indicated that they had not covered the intended topic 'estimation and number sense' and five teachers' reports indicated that they had not covered 'problem solving strategies' in term 1.

This data reveals that

- not all of the teachers covered the same topics; and
- different teachers gave more emphasis to different topics/ subtopics.

6.2 Reports on teachers' instructional practices in Grade 4 Maths classes (i.e. how the teachers taught the topics/subtopics)

The following section provides information on the implemented curriculum in terms of

- aspects of teachers' lessons that were observable; and
- information obtained through direct interviews with the teachers after they had finished teaching the lessons.

6.2.1 Reports on practices/aspects of classroom teaching not covered in terms of the criteria used for the classroom observations (see 6.2.2 for reports on practices in terms of the criteria)

Included in this section are fieldworkers' reports on:

- classroom organisation (see 6.2.1.1);
- use of the language/s of learning (see 6.2.1.2); and
- use and availability of textbooks, technology and other material resources (see 6.2.1.3)

6.2.1.1 Classroom organisation

Fieldworkers reported that eleven of the twelve teachers used whole class teaching to introduce, explain and/or demonstrate the concepts, principles or strategies that learners were expected to use in the activities/exercises provided. Three of the eleven teachers made use of group work/learners working in pairs. Six gave learners work to complete on their own. The twelfth teacher (teacher 9) used group work only. None of the teachers reported grouping learners according to ability.

6.2.1.2 Language/s of learning

Included in this section is information on language/s most used

- by the teacher in teacher-learner interactions;
- by the learners in teacher-learner interactions;
- by the learners in learner-learner discussion;
- in the activities/exercises provided.

Six teachers used English/Xhosa but mainly Xhosa in teacher-learner interactions. Four teachers used English and Xhosa but mainly English. Two teachers used Xhosa.

In all twelve of the lessons observed learners mainly used Xhosa in teacher-learner interactions. Learners used English mainly for naming numbers and for Maths notation.

Opportunities for learner-learner discussion were provided in four of the twelve lessons observed (see 6.2.2.1). In all four lessons learners spoke to each other in Xhosa.

Summary

Teachers used English and/ or Xhosa in class~yr ~om interactions. Learners mainly used Xhosa in classroom interactions, but used English to name numbers and Maths notation. The classroom activities that were provided almost always took the form of numbers and Maths notation.

6.2.1.3 The availability and use of textbooks, technology and other material resources in Grade 4 Maths classes

This section provides background information on teachers' use of

- textbook/s; and
- technology and other material resources.

Textbooks

Six teachers reported that they used learner textbooks to plan the lessons observed. Five teachers reported that they relied on their own previously planned lessons. One teacher reported relying on the learner textbook as well as her own previously planned lesson.

Eight teachers reported that they used the learner edition of textbooks to select problems and exercises for class/homework in the lessons observed. One teacher reported using the Interim syllabus for the Western Cape, and one teacher reported using the teacher edition of the textbook.

Teachers/fieldworkers reported that ten teachers used textbooks either during or to plan the lessons observed. Two teachers did not use textbooks. Four teachers used two or more textbooks.

Data on the titles of the textbooks used by the teachers during the lessons observed, or that teachers reported using to plan the Grade 4 Maths lessons observed reveals considerable variation in the textbooks used by the teachers. Classroom Mathematics 2 and Just Maths 2 were each used by four teachers, Modern Basic Maths was used by two of the teachers; and Classroom Mathematics 1; Successful Maths 2, Active Mathematics std 2, Maths for all 2 and Mathematics in Practice by one teacher each.

Use of technology and other material resources

Three of the twelve teachers used worksheets / workcards in the lessons observed. The majority of teachers copied work onto the chalkboard

Half the teachers used support material such as Flard cards, Cuisenaire rods/Dienes blocks, flash cards, number pattern cards in the lessons observed.

Use of calculators

Use was made of calculators in two of the twelve lessons observed. In Teacher 7's lesson one calculator was available per three learners. In Teacher 10's lesson each learner had his/her own calculator.

6.2.2 Fieldworkers' reports on instructional practices in terms of the criteria used for the study

This section provides information on observable classroom practices in terms of the criteria developed to describe:

- classroom interactions (see 6.2.2.1)
- the activities learners did in the Maths lessons (see 6.2.2.2)
- teachers' approaches to assessment (see 6.2.2.3)

Data from the video recordings of teachers' lessons has been combined with data from the observation schedules to construct vignettes or short descriptions of the lessons observed. The vignettes provided interesting insights into teachers' Mathematics teaching. Extracts from the vignettes have been used in the analysis which follows to illustrate qualitative similarities and differences in teachers' practices in terms of the each of the criterion used for the observation schedules (see Appendix P).

6.2.2.1 Classroom interactions

The criteria used to describe classroom interactions are:

- Does the teacher engage learners in discourse relevant to the Mathematics concepts, principles or strategies to be learnt? (Criterion 1);
- Does the teacher explain the Maths concepts, principles or strategies to be learnt? (Criterion 2);
- Does the teacher demonstrate how the Maths concepts, principles or strategies to be learnt work? (Criterion 3); and
- Does the teacher organise learner-learner discussion about the Maths concepts, principles or strategies to be learnt? (Criterion 4)

Criterion 9

Table 10 provides a summary of fieldworkers' reports on teachers' engagement of learners in discourse relevant to the Mathematics concepts, principles or strategies to be learnt.

TABLE 10: TEACHERS' ENGAGEMENT OF LEARNERS IN DISCOURSE

Teacher	1	2	3	4	5	6	7	8	9	10	11	12
Indicator	2	2	4	4	5	3	2	4	2	3	4	3
Indicators: 1 = Teacher does not introduce learners to additional Maths language or engage learners in discourse (discussion) about the Mathematics concepts, principles or strategies. For example, by not providing them the opportunity to speak or mainly involving them in answering questions which require yes or no responses 2 = Teacher introduces learners to additional Maths language but models technically/ Mathematically incorrect or inappropriate language. 3 = Teacher introduces learners to additional Maths language. Teacher engages learners in surface articulation of Maths language by focusing on form rather than meaning. Teacher does not engage learners in discourse (discussion) about the Mathematics concepts, principles or strategies. For example, through involving learners in verbally repeating what the teacher tells them about the concepts, principles or strategies or in labelling. 4 = Teacher introduces learners to additional Maths language and focuses on meaning rather than form. Teacher does not engage learners in discourse												

(discussion) about the Mathematics concepts, principles or strategies or involves them in articulating/ communicating what they already know about the concepts, principles or strategies (i.e. using their existing everyday and Mathematics knowledge and language). Teacher does not extend learners' own repertoire of Maths language by providing them with the opportunity to practice using new Maths language to formalise their thinking and understanding of the concepts, principles or strategies further. For example, through involving learners in using their existing everyday and Maths language to explain what they think or how they would solve new problems even when the language they use is technically/Mathematically incorrect or inappropriate.

5 = Teacher introduces learners to additional Maths language and focuses on meaning rather than form. Teacher extends learners' repertoire of Maths language by providing them with the opportunity to practice using new Maths language to formalise their thinking and understanding of the concepts, principles or strategies further. For example, by asking learners to explain why they think what they do and using those aspects of their explanations which are useful to provide them with the Maths language they need to formalise their thinking and understanding of the concepts, principles and strategies further.

Analysis

All twelve teachers introduced learners to additional/new Maths language. Four teachers modelled technically/Mathematically incorrect or inappropriate language and were given a rating of 2. These teachers used conceptually misleading language/definitions and, as a result, demonstrated incorrect conceptions of the Maths concepts, principles or strategies to be learnt.

For example, Teacher 1 told learners that 'expanded notation' is 'when the number gets bigger' when she wanted to explain that they could give or get a 'fuller account' of whole numbers by using Maths notation to represent numbers in terms of the value of their component parts. She provided learners with an incorrect definition of 'expanded notation'. She also provided them with a conceptually misleading explanation of the use expanded notation and hundreds, tens and units columns by saying that they could 'divide 27 according to this pattern' (expanded notation), and 'use columns to divide numbers into hundreds, tens and units'. She did not explain that both procedures involved representing, placing and arranging (not dividing) whole numbers according to the value of their component parts. She did not make the differences between the two procedures explicit.

Teacher 7, who was teaching calculator skills, asked learners to 'estimate' the cost of groceries. However, learners were merely required to make up prices by guessing. No Mathematical reasoning was involved and learners were not asked to justify their estimates. Teacher 9, who was teaching learners about place value, did not use language in ways that assisted learners to relate the value of digits in whole numbers to their position ('place'). Instead she asked learners 'What number does the one (in the number 12) stand for? What does the 2 stand for?' and made no reference to underlying system.

Three teachers were given a rating of 3 for engaging learners in surface articulation of Maths language by focusing on form rather than meaning. For example, Teacher 10, who was teaching learners calculator skills,

focused their attention on using the 'correct' procedures by saying, 'Press these numbers on your calculators - one, eight, five, two and the equal sign'. She did not use language to focus learners' attention on understanding the concept of 'place value'. Teacher 12 used phrases such as 'smaller than...' and 'bigger than...' to describe the difference between thousands, hundreds, tens and units but did not explain or check that learners understood these concepts.

Five of the twelve teachers introduced learners to appropriate additional Maths language and focused on meaning rather than form. Four of the five teachers were given a rating of 4. For example, teacher 3 provided learners with the necessary Maths notation and terminology to explain the four basic operations of addition, subtraction, multiplication and division. In this way he provided learners with a variety of appropriate alternative/equivalent terms that assisted them to understand and express the basic operations to be learnt (for example, addition or plus sign; subtraction or minus sign). Teacher 4 also provided learners with appropriate Maths notation and terminology to explain the four basic operations of addition and subtraction. She asked individual learners to come up to the front of the class and select written forms of the Maths notation from a box containing pieces of cardboard with terms such as 'ADDITION SIGN' written out in full. She provided learners with an accurate definition of the term 'sum' by saying, 'When we add, the answer is called the sum.'

Teacher 8, who was teaching the topic 'place value', instructed learners to 'arrange 498 according to the value of the digits. That is arrange the digits according to their values. ' She used the correct term, 'digits' (as opposed to numbers) and focused learners' attention on the relationship between the value of the digits and their position in whole numbers. Teacher 11 assisted learners to think about and understand the value of digits in whole numbers. For example, by saying, 'When you are talking about place values (sic), you are talking about taking digits to hundreds, tens and units. When you are talking about 100s, you are talking about a hundred things. When you are talking about 10s, you are talking about ten things. When you are talking about units, you are talking about one thing.'

Teachers who focused on meaning rather than form used language to assist learners to make connections/ links between their existing everyday understandings and the Maths concepts, strategies and principles to be learnt. Some teachers explained 'place value' by saying that 'all digits have their own homes.' However, they did not always use language to make the connections between related concepts, strategies and principles explicit. For example, by focusing learners' attention on the procedure of placing digits in the correct position rather than using language to assist them to understand the relationship between the concepts 'place' and 'value' by focusing their attention on the value of the position/ place of digits in whole numbers.

In eleven of the above lessons, learners were engaged in providing short answers while the teachers themselves explained to the class. Learners were provided with little/no opportunities to explain and discuss their Mathematical thinking or to use Maths language to express their own understandings of the Maths concepts, principles or strategies being learnt. As a result, teachers did not assist learners to make links/ connections between their existing understandings as expressed by the learners themselves in their primary language and the new discourse/concepts, principles or strategies. Neither were teachers able to use learners' expressions of their understandings of the concepts, principles or strategies to assist them to understand differences between the Maths concepts, principles or strategies and their everyday or 'out of school' understandings.

Only one of the teachers was given a rating of 5 for focusing on meaning, and for extending learners' repertoire of Maths language by providing them with the opportunity to practice using new Maths language to formalise their thinking and understanding of the concepts, principles or strategies.

Teacher 5, who was teaching the basic operation of addition, explained that a plus sign indicated 'direction'. He did not say that the sign meant that the number 'gets bigger' as this would have implications in terms of learners later acquiring an understanding of 'integers' (positive and negative numbers). During the course of the lesson he invited a learner to explain his solution and thinking to the whole class in his primary language (Xhosa).

Criterion 2

Table 11 summarises fieldworkers' reports on teachers' explanations of the Maths concepts, principles or strategies to be learnt.

TABLE 11: TEACHERS' EXPLANATIONS

Teacher	1	2	3	4	5	6	7	8	9	10	11	12
Indicator	2	4	5	5	5	4	1	2	2	2	4	2
Indicators: 1= Teacher does not explain the Mathematics concepts, principles or strategies. 2= Teacher explains the Mathematics concepts, principles or strategies but mismanages the explanations. For example, by teaching the wrong concepts, principles or strategies; by pitching the explanations at an inappropriate level for the learners (too high/too low); or by using incorrectly drawn representations, etc. 3= Teacher explains the Mathematics concepts, principles or strategies but does not explain the reason for focusing on them or learning them. 4= Teacher explains the Mathematics concepts, principles or strategies and the reason for focusing on them or learning them. Teacher does not illustrate how they can be used elsewhere in past, present and future problems. For example, by explaining place value and telling learners that it is useful for addition and subtraction but not actually illustrating its relevance in terms of algorithms etc. 5=Teacher explains the Mathematics concepts, principles or strategies and the reason for focusing on them or learning them. Teacher illustrates how they can be used elsewhere in past, present and future problems.												

Analysis

Only one of the twelve teachers in the sample was given a rating of one for not explaining the Mathematics concepts, principles or strategies to learners.

Teacher 7 used an everyday/real life experience, 'shopping', as an entry point for the Maths concepts, principles or strategies to be learnt. However, he did not explain how an algorithm using addition worked or how learners could actually use calculators to calculate the cost of groceries. As a result, the Mathematical purpose of the lesson, how to do the four basic operations using a calculator was lost.

Of the eleven teachers who explained the Mathematics concepts, principles or strategies to be learnt, five teachers mismanaged their explanations, and were given a rating of 2. For example, Teacher 1 used the number 302 to explain, 'place value' but did not provide learners with an explanation of 0 as a place holder.

Teacher 8 explained the concept of 'carrying' in subtraction in the following:

$$\begin{array}{r} 528 \\ - 219 \\ \hline \end{array}$$

by saying 'if you have 8 oranges, you can't take 9 oranges from 8 oranges.' She did not explain that learners could take ten from the tens column to 'make' the eight oranges eighteen oranges. She told learners that addition and subtraction are 'the same' procedures but did not explain the difference between the two procedures.

Teacher 9 explained 'place value' by asking learners to hold up (number) cards to form the number 12 and asked learners what the two numbers 'stand for.' Some learners held two cards together to form 12 when one card had 1 (unit) and the second card had 2 (units) written on it instead of two cards - one with 10 written on it and another with 2 written on it. Some learners used $7 + 1 + 2$ to form 712 rather than $700 + 10 + 2$. The teacher did not explain the relationship between the value of the digits and their place in whole numbers.

Teacher 12 explained 'place value' using the number 125. She told learners that the 'thousands are missing' but did not make it clear that the place value 'thousands' still existed in its abstract form. In other words, she explained place value in terms of actual (concrete) numbers/digits rather than explaining the relationship between the numbers/digits and the (abstract) concept of 'place value'.

Three of the teachers were given a rating of 4 for explaining the reason for focusing on the concepts, principles or strategies. However, even though these teachers provided appropriate explanations, it was not always clear whether learners had understood their explanations. In at least half of the lessons observed, learners' own work revealed that the

teachers had not managed to make the concepts, principles or strategies to be learnt clear to at least 25% of the learners.

Three of the eleven teachers were given a rating of 5 for explaining the reason for focusing of the concepts, principles or strategies and illustrating how they could be used elsewhere in past, present and future problems. For example, Teacher 3 explained that, 'A number is made up of digits. Digits differ according to their values. For example' (the teacher wrote the following on board):

1 = a single digit number or a one digit number 11 = a double digit number or a two digit number 111 = a three digit number.

The teacher went on to explain that $1 = 1$; $11 = 10 + 1$; $111 = 100 + 10 + 1$. In this way he eliminated one variable at a time and made the relationship between the position of digits and their value clear. He also demonstrated the use of place value in addition saying, 'Let's use place value to do the following addition.'

Teacher 5 explained the relationship between the position of digits in whole numbers and their value. He emphasised the importance of understanding place value and explained that the concept of place value could be used/applied in a number of applications. For example, by saying, 'You won't make mistakes when you add if you understand place value... You must be very accurate in your use of place value... When you subtract you will use place value... If you understand place value, no matter what number you are given you will be able to add... If you have R10 and you buy something for 39 cents and 45 cents you must be able to count your change otherwise you will be cheated.'

Criterion 3

Table 12 summarises fieldworkers' reports on teachers' demonstrations of how the Maths concepts, principles or strategies to be learnt work.

TABLE 12: TEACHERS' DEMONSTRATIONS

Teacher	1	2	3	4	5	6	7	8	9	10	11	12
Indicator	4	4	4	4	5	4	3	2	1	1	4	2
Indicators: 1 = Teacher does not demonstrate how new Mathematics concepts, principles or strategies work. 2 = Teacher uses unfamiliar, indirect, Mathematical imagery, abstractions or representations to demonstrate how new Mathematics concepts, principles or strategies work. 3 = Teacher uses concrete or physical representations or examples from learners' real-life experiences e.g. counters, sketches, pictures, money, number lines, analogies etc. to demonstrate how new/unfamiliar Mathematics concepts, principles or strategies work. Teacher focuses learners' attention on the actual representations or real-life experiences rather than on the relationship between the representations or real-life experiences and the Maths concepts, principles or strategies 4 = Teacher uses multiple representations including concrete or physical representations and indirect Mathematical representations or examples from												

learners' real life experiences to demonstrate how new/unfamiliar Mathematics concepts, principles or strategies work. Teacher focuses learners' attention on the relationship between the new Mathematics concepts, principles or strategies and the representations or real-life experiences. Teacher does not demonstrate how the new Mathematics concepts, principles or strategies are generalised and applied to solve problems of a homologous Mathematical form.

5= Teacher uses multiple representations including concrete or physical representations and indirect Mathematical representations or examples from learners' real life experiences to demonstrate how new Mathematics concepts, principles or strategies work. Teacher focuses learners' attention on the relationship between the new Mathematics concepts, principles or strategies and the representations or real-life experiences. Teacher demonstrates how the new Mathematics concepts, principles or strategies are generalised and applied to solve problems of a homologous Mathematical form. For example, by restating familiar problems in more general and widely applicable terms through the use of the Mathematics concepts, principles or strategies (i.e. indirect Mathematical imagery, abstractions or representations).

Analysis

Two of the twelve teachers were given a rating of two because they did not demonstrate how the new Mathematics concepts, principles or strategies worked. For example, Teacher 9 did not demonstrate how the new Maths concepts, principles and strategies worked. Instead the learners themselves were expected to use number cards in ways that 'revealed' 'place value' relationships.

Of the remaining ten teachers who did demonstrate - two teachers used unfamiliar, indirect, Mathematical imagery, abstractions or representations to demonstrate and were given a rating of 2. For example, Teacher 12 used whole numbers to demonstrate 'place value' but did not demonstrate the concept of 'place value' through the use of other representations or through using examples from learners' real life experiences.

One teacher used concrete or physical representations or examples from learners' real-life experiences but focused learners' attention on the actual representations or real-life experiences rather than on the relationship between the representations and real-life experiences and the Maths concepts, principles or strategies themselves, and was given a rating of 3. Teacher 7 used a 'real-life experience', grocery shopping, as a context for demonstrating calculator skills. He used the following list of prices to demonstrate/show learners how to do an algorithm using addition:

R 4.99

R 6.79

R 3.50

R 2.90

R 3.98

R22.50

However, he did not actually demonstrate how an algorithm using addition works.

Seven teachers used multiple representations to demonstrate and focused learners' attention on the relationship between the new

Mathematics concepts, principles or strategies to be learnt and the actual representations or real-life experiences themselves. Six of these teachers were given a rating of 4. For example, Teacher 1 used Flard cards, hundreds, tens and units i.e.

H	T	U

as well as expanded notation to explain place value. She did not demonstrate how place value could be used elsewhere to solve similar problems, for example, by demonstrating which of the following is the largest number-735; 737; 573; 753 (see TIMSS item M-8).

Teacher 2 used Flard cards, thousands, hundreds, tens and units, picture representations in the textbook, and the following 'abacus' to demonstrate place value:

Th	H	T	U
X	X		X
X	X		X
X			X
			X
			X
3	2	0	5

Teacher 3 demonstrated place value by using hundreds, tens and units to illustrate the number 111 as follows:

H	T	U
1	1	1

He also used expanded notation and units, tens and hundreds columns to demonstrate the use of place value in addition. For example,

$$17+13 \quad 17=10+7$$

$$13=10+3$$

$$\underline{20+10=30}$$

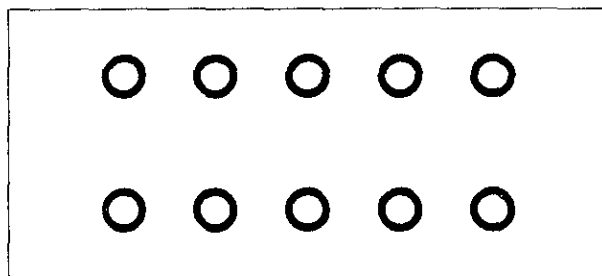
and 121 as

H	T	U
1	2	1

and $100 + 20 + 1$. However, he did not relate either of the procedures to other more complex procedures.

Teacher 6 demonstrated the concepts, principles/strategies to be learnt through a set of sequenced examples. She started the lesson by getting

learners to count in ones to one hundred and in hundreds to one thousand. She then used flash cards to get learners to add and subtract using mental arithmetic. For example, by flashing cards with $6 + 4 =$ and $7 \times 3 =$, etc. She showed learners a card with 10 'balls' as illustrated below:



She held the card horizontally (as above) and asked the learners to make a 'sum' using the ten balls (i.e. $2 + 2 + 2 + 2 + 2 =$). She then turned the cards vertically and asked the learners to think of a 'shorter way' of showing this (i.e. $2 \times 5 =$). She proceeded to use hundreds, tens and units to demonstrate addition and subtraction as follows:

H	T	U
3	2	4
+1	3	6
4	6	0

and

H	T	U
5	7	4
-3	2	5
2	4	9

Teacher 11 used number/Flard cards to demonstrate how to 'build' numbers. She used the cards to demonstrate the difference between 205 and 25 as

200	5
-----	---

and

20	5
----	---

She demonstrated that 216 is comprised of hundreds, tens and units, in other words, she demonstrated that this number is not simply $200 + 16$ but $200 + 10 + 6$. She provided learners with wooden blocks representing 100s, 10s and units. Learners were also provided with representations of these blocks in the photocopy of an activity from a textbook. However, a large percentage of lesson time was taken up distributing these resources.

One of the seven teachers demonstrated how the new Mathematics concepts, principles or strategies are generalised and applied to solve

problems of a homologous Mathematical form, and was awarded a rating of 5. Teacher 5 used learners to form a 'human' abacus to demonstrate place value. He demonstrated how principles and rules for 10s and units apply to hundreds as well. He also demonstrated the importance of placing digits in the appropriate 'place' according to their value when adding numbers. The teacher used examples such as the following to demonstrate place value and 'carrying over' in addition.

T	U
4	5
+3	9
8	4

14
Teacher: 'Remember the plus sign shows direction.'

Overall two trends were evident in teachers' lessons. Teachers tended to select and focus their demonstrations either on

- a) those aspects of the concepts, principles or strategies that learners found easiest (for example, procedural issues such as arranging digits in the correct 'place' , or basic operations such as addition and subtraction rather than on more complex procedures such as division and multiplication); or on
 - b) learners' everyday/ real-life experiences (such as shopping) rather than on how they could use or apply the Maths concepts, principles or strategies being taught to solve problems in their everyday life.
- Criterion 4

Table 13 summarises fieldworkers' reports on how teachers organised learner-learner discussion about the Maths concepts, principles or strategies to be learnt.

TABLE 13: TEACHERS' ORGANISATION OF LEARNER-LEARNER DISCUSSION

Teacher	1	2	3	4	5	6	7	8	9	10	11	12
Indicator	3	3	1	1	1	1	1	1	3	1	3	1

Indicators:

1 = Teacher does not provide learners with opportunities to discuss the Mathematics concepts, principles or strategies together

2 = Teacher provides learners with opportunities to discuss the Mathematics concepts, principles or strategies together by encouraging them to check one another's answers.

3 = Teacher provides learners with opportunities to discuss the Mathematics concepts, principles or strategies together by encouraging them to help one another but does not organise the discussion in ways that learners can benefit from each other's thinking/discourse (Maths language).

4 = Teacher provides learners with opportunities to discuss the Mathematics concepts, principles or strategies together by encouraging them to help one another and by organising the discussion in ways that learners can benefit from each other's thinking/discourse. For example, through organising carefully structured co-operative group or paired problem-solving tasks (i.e. tasks which have been structured in ways which have been designed to involve them in discussing ideas and sharing skills, in negotiating and explaining their thinking to one another, in evaluating each others' methods, problem-solving strategies etc.)

Teacher does not teach or model the skills learners need to work collaboratively.

5= Teacher provides learners with opportunities to discuss the Mathematics

concepts, principles or strategies together by encouraging them to help one another and by organising the discussion in ways that learners can benefit from each other's thinking/discourse. Teacher teaches or models the skills learners need to discuss the concepts, principles or strategies together and to help one another. For example, how to share ideas, how to negotiate, how to explain their thinking, how to evaluate each other's method, how to problem-solve collaboratively etc.

Analysis

Although learners in most classes were seated in pairs or groups, there was very little/no constructive learner-learner discussion in any of the classes observed (for example, through learners solving problems together, or explaining their solutions to one another or the rest of the class). Eight of the twelve teachers did not provide learners with opportunities to discuss the Maths concepts, principles or strategies together, and were given a rating of 1. For example, in Teacher 7's lesson there were insufficient calculators for each learner to use on his/her own. Learners had to share one calculator between two/three learners. Although the teacher told them that they 'must share the calculators', most learners did not collaborate with each other by sharing. The teacher ignored rather than rectified this situation.

In the few lessons where teachers encouraged learners to work together (teachers 1,2,9 and 11), teachers did not organise the activities or discussion in ways that ensured that learners shared ideas, explained their thinking or problem-solved collaboratively. Four teachers were given a rating of 3 for providing learners with opportunities to discuss the Mathematics concepts, principles or strategies together by encouraging them to help one another. However, they did not organise the discussion in ways that learners could benefit from each other's thinking or language. For example, although Teacher 11 encouraged learners to compete in groups, learners within groups did not discuss their thinking and understanding, or work effectively together.

6.2.2.2 Activities learners did in their Maths lessons

Criteria used to describe activities learners did in their Maths lessons include:

- Does the teacher provide opportunities for learners to participate in practising using the Maths concepts, principles or strategies to be learnt? (Criterion 5); and
- Does the teacher structure Mathematics activities through which learners experiment with using new Maths concepts, principles or strategies to solve problems? (Criterion 6)

Criterion 5

Table 14 summarises fieldworkers' reports on teachers' provision of opportunities for learners to participate in practising using the Maths concepts, principles or strategies to be learnt.

TABLE 14: LEARNERS' OPPORTUNITIES TO PRACTICE

Teacher	1	2	3	4	5	6	7	8	9	10	11	12
Indicator	4	3	4	4	4	4	2	2	3	3	3	2

Indicator:

1 = Teacher does not provide learners with opportunities to participate in practising using the Mathematics concepts, principles or strategies themselves. For example, by doing the mental work and solving problems for the class.

2 = Teacher provides learners with opportunities to participate in practising surface articulation of the Mathematics concepts, principles or strategies. Teacher focuses on form rather than meaning. For example, through repeating addition, subtraction, division and multiplication tables by rote.

3= Teacher provides learners with opportunities to participate in practising using the Mathematics concepts, principles or strategies in ways that encourage them to rely on concrete or physical representations (such as counters or fingers). Teacher does not assist learners to practice using more indirect and formal Mathematical abstractions or representations and procedures (such as algorithms) and/or to estimate and calculate mentally. For example, by allowing learners to rely on using their fingers for counting on; for repeated addition/subtraction; and for practising division as repeated subtraction or multiplication as repeated addition

4= Teacher provides learners with opportunities to participate in practising using the Mathematics concepts, principles or strategies in a variety of ways that assist them to use more indirect or formal Mathematical abstractions or representations and procedures (such as algorithms) and/or to estimate and calculate mentally rather than encouraging them to rely on concrete or physical representations. For example, by providing learners with opportunities to practice repeating addition, subtraction, division and multiplication tables, using concrete or physical representations for counting on, through number bonds/calculations such as adding and subtracting two digit numbers and multiplying and dividing multiples of 10 by one digit numbers. . Teacher does not provide learners with opportunities to practice using the concepts, principles or strategies in a variety of applications.

5= Teacher provides learners with opportunities to participate in practising using the Mathematics concepts, principles or strategies in a variety of ways that assist them to use indirect or formal Mathematical abstractions and representations and/or to estimate and calculate mentally rather than encouraging them to rely on concrete or physical representations. Teacher provides learners with opportunities to practice using the concepts, principles or strategies in a variety of applications. For example, translating word problems into number sentences.

Analysis

All twelve of the sample of teachers provided learners with opportunities to participate in practising using the Maths concepts, principles or strategies themselves. Three of the teachers provided opportunities for learners to practice surface articulation of the concepts, principles or strategies, and were given a rating of 2. For example, in Teacher 7's lesson the learners 'practised' calling out items for a grocery list; guessing the cost of the groceries; reading out the names or makes of their calculators for the teacher to write on the board; and telling the teacher 'what they can see on the calculator' (for example, the numbers 0 - 9, the 'on' and 'off' switches, etc.)

Although the teacher provided learners with a 'mix' of activities, the activities were not integrated or organised sequentially in ways that assisted learners to practice the necessary concepts and skills incrementally. The learners practised using their calculators while the

teacher called out, '1 plus zero plus 5 is equal to? What is the answer? 40 plus 20 is equal to? What is the answer?'

Teacher 8 provided learners with opportunities to practice examples such as the following:

$$\begin{array}{r} 5387 \\ -3258 \\ \hline \end{array}$$

She explained that they could not subtract 8 from 7 and told learners they had to borrow 1 from 8 and then subtract 8 from 17 to get 9. She told them they could check to see if their answer was correct by using the inverse of subtraction i.e. by adding $9 + 8$ to get 17. A number of learners were unable to follow as they lacked the skills to calculate mentally and were still using their fingers to count on.

Teacher 12 focused learners' attention on using the 'correct' procedures and not on the concepts underpinning the procedures. For example, by asking learners, 'Who can put these numbers in these columns?'

2848

Th	H	T	U

Four teachers encouraged/allowed learners to rely on concrete and physical representations when they practised, and were rated as 3. For example, Teacher 2 provided learners with Cuisenaire rods when the textbook already provided picture representations of the rods. A number of learners in her class also used their fingers or other representations for 'counting on'.

Teacher 9 gave each group of learners number charts as illustrated below:

1 000	100	10
2 000	200	20
3 000	300	30
4 000	400	40
5 000	500	50
6 000	600 etc.	

The learners had to place number cards over these in a matching task. However, the teacher did not focus learners' attention on the relationship between thousands, hundreds and tens. Learners were expected to use the resources in ways that 'revealed' 'place value' relationships to them.

Teacher 10 used an unfamiliar context (a crossword puzzle) to teach calculator skills. Although the learners practised calculator skills, the

teacher did not provide them with opportunities to practice estimating their answers.

Four teachers encouraged/assisted learners to use more indirect or formal Mathematical abstractions or representations and procedures and/or to estimate and calculate mentally, and were given a rating of 4. For example, in Teacher 1's lesson the learners practised using hundred, tens and units to 'build' whole numbers and expanded notation to 'break' whole numbers into their component parts, for example $25 = 20 + 5$ and $302 = 300 + 2$.

Teacher 3 encouraged learners to use routine Maths procedures to calculate by saying, 'Let's use place value to do the following addition'

$$\begin{array}{r} 100 \\ 10 \\ 1 \\ \hline 11 \\ 11 + 25 \\ 11 = 10 + 1 \\ \underline{25 = 20 + 5} \\ 30 + 6 \\ \text{Answer: } 36 \end{array}$$

$$\begin{array}{r} 14 + 13 \\ 14 = 10 + 4 \\ \underline{13 = 10 + 3} \\ 20 + 7 \\ \text{Answer: } 27 \end{array}$$

$$\begin{array}{r} 17 + 15 \\ 17 = 10 + 7 \\ \underline{15 = 10 + 5} \\ 20 + 12 \\ (20 + 10) + 2 \\ \text{Answer: } 32 \end{array}$$

The teacher asked learners the value of 1 in the number 12 and explained that they had to 'carry' the ten to the tens.

In Teacher 4's lesson learners practised routine Maths procedures including using 0 as a placeholder. For example:

$$\begin{array}{r} 5 + 52 + 501 \\ \text{H} \quad \text{T} \quad \text{U} \\ \quad \quad \quad 5 \\ \quad \quad 5 \quad 2 \\ \underline{5 \quad 0 \quad 1} \\ 5 \quad 5 \quad 8 \end{array}$$

In Teacher 5's lesson, learners practised using a variety of graded/sequenced 'demonstration' tasks that the teacher had organised in order of complexity. For example,

1) $35 + 4$

T	U
3	5
+	4

2) $45 + 39$

T	U
4	5
+3	9

3) $351 + 25$

The teacher used example 2 to demonstrate that learners had to, 'Remember the one (in 14) counts as tens. Do it (carry it over) before you forget it. If you leave it (out), you start with a mistake.'

In Teacher 6's class learners practised counting in ones and hundreds and doing mental arithmetic. They practised making number sentences using addition and multiplication. They also practised writing the following numbers in the correct columns according to the place value of the digits:

3161
29
3
74
129
30
360
5

Th	H	T	U

None of the teachers provided learners with opportunities to practice using the concepts, principles or strategies in a variety of applications such as translating word problems into number sentences.

Overall learners spent a large proportion of time practising/ revising work that they would/should have covered in the Foundation/Junior Primary Phase. In all the lessons (except for Teachers 5 and 6's lessons) learner: did not practice using increasingly complex examples that assisted them

to develop their understanding and use of Maths concepts, principles or strategies in progressively difficult ways, or to apply new Maths concepts, strategies or principles to real-life problems.

Criterion 6

Table 15 summarises fieldworkers' reports on teachers' structuring of Mathematics activities through which learners experiment with using new Maths concepts, principles or strategies to solve problems.

TABLE 15: TEACHERS' STRUCTURING OF MATHS ACTIVITIES

Teacher	1	2	3	4	5	6	7	8	9	10	11	12
Indicator	1	2	4	4	4	4	2	4	2	5	2	2

Indicators:

1 = Teacher does not structure Mathematics activities or tasks in ways, which provide learners with opportunities to experiment with using the Mathematics concepts, principles or strategies to solve problems. For example, by not providing the learners with the opportunity to grapple with problems themselves.

2 = Teacher structures Mathematics activities or tasks in ways which provide learners with opportunities to experiment with using their current Mathematical and everyday knowledge of the Mathematics concepts, principles or strategies to solve **routine** problems even if they are not using the most efficient or effective ways of solving the problems. For example, by providing them with opportunities to experiment with using algorithms but allowing them to use concrete or physical representations such as fingers to calculate.

3 = Teacher structures Mathematics activities or tasks in ways which provide learners with opportunities to experiment with using their current Mathematical and everyday knowledge of the Mathematics concepts, principles or strategies to solve **routine** and **novel** problems (problems for which learners cannot immediately solve using a routine method) even if they are not using the most efficient or effective ways of solving the problems.

4 = Teacher structures Mathematics activities or tasks in ways which provide learners with opportunities to experiment with using the new concepts, principles or strategies to solve **routine** problems more efficiently or effectively. Teacher does not provide learners with opportunities to experiment with using the Mathematics concepts, principles or strategies to solve **novel** problems more efficiently or effectively. For example, by providing them with opportunities to experiment with using algorithms and encouraging them to estimate and calculate mentally.

5 = Teacher structures Mathematics activities or tasks in ways which provide learners with opportunities to experiment with using the new Maths concepts, principles or strategies to solve **routine** and **novel** problems more efficiently or effectively. For example, by providing them with opportunities to experiment with problems which have no obvious solution through hypothesising, predicting, estimating, investigating, exploring, and discovering patterns and connections through matching, ordering, sorting etc.

Analysis

Only one teacher did not structure Mathematics activities or tasks in ways, which provided learners with opportunities to experiment with using the Mathematics concepts, principles or strategies to solve problems, and was given a rating of one. In Teacher 1's class the learners did not experiment with problem-solving activities themselves but practised 'building' numbers in terms of hundreds, tens and units as a class.

The following is an example of a Maths exercise learners were expected to complete in Teacher 4's lesson:

204 + 3 + 21

H	T	U
2	0	4
		3
	2	1
2	2	8

Learners practised using 0 as a place holder.

The following were activities completed by Teacher 5' class for homework:

- 1) 625+52
- 2) 734+72
- 3) 592+53+78
- 4) 216+35+6+567

In Teacher 6's lesson, the learners completed the following: 1) 274+2+23=

2) 314 + 259 = 3) 462-129=

Learners in Teacher 8's lesson completed algorithms using subtraction as illustrated below:

978 - 569, i.e.

978
-569

- 1) 3575 -2385
- 2) 5987-3896
- 3) 7865 -3995

Only one of the teachers was given a rating of 4 for providing learners with opportunities to experiment with using the new concepts, principles or strategies to solve routine and novel problems more efficiently or effectively (in other words, to use process skills such as recognising and discovering patterns etc.). In Teacher 10's lesson, learners completed a crossword puzzle activity (See Appendix P).

However, the activity was inappropriate because the context (a crossword puzzle) was too unfamiliar to most of the learners. The teacher had to focus attention on addressing learners' unfamiliarity with the context and assisting them to recognise the 'words' from the numbers on their calculators. As a result, the Mathematical purpose of the activity, how to do the basic operation of addition using a calculator was lost.

With the exception of Teacher 8's class, most of the activities covered work that learners should have mastered in the Junior Primary/Foundation Phase. Teacher 8's lesson was the only lesson in which the learners addressed the more complex operation of subtraction (as opposed to addition). This goes some way towards explaining why approximately 50% of the learners in her lesson were unable to complete the activities.

All learners in each of the lessons observed completed the same activities. Answers to the activities almost always consisted only of numbers or numbers and Maths notation. Activities generally involved using routine procedures (such as adding and subtracting), or using conventional approaches to solving problems rather than using more complex procedures (such as estimating). Learners were not provided with opportunities to use Maths notation and/ or vocabulary to represent real-life problems, or to use Mathematical reasoning or problem solving strategies to solve problems creatively. Instead the activities encouraged conformity rather than independent or complex thought. Teachers tended to control the ways in which the learners completed activities. None of the activities involved learners in considering multiple approaches to solving problems or in explaining their thinking/reasoning.

6.2.2.3 Approach to assessment

The criterion used to describe teachers' approach to assessment was:

- does the teacher assess whether learners have learnt the Maths concepts, principles or strategies that the teachers intended to teach? (Criterion 7)

Criterion 7

Table 16 summarises fieldworkers' reports on teachers' assessment of whether learners have learnt the Maths concepts, principles or strategies that the teachers intended to teach.

TABLE 16: TEACHERS' ASSESSMENT

Teacher	1	2	3	4	5	6	7	8	9	10	11	12
Indicator	3	3	3	4	4	3	2	3	2	2	4	3
Indicators: 1 = Teacher does not assess whether learners have learnt the Mathematics concepts, principles or strategies during normal learning activities. 2 = Teacher assesses whether learners have learnt the Mathematics concepts, principles or strategies within the context of tasks during normal learning activities but mismanages the assessment. For example, by mismatching the tasks with the concepts, principles or strategies to be assessed; by assessing the wrong concepts, principles or strategies; by incorrectly assessing the concepts, principles or strategies; etc. 3 = Teacher assesses whether learners have learnt the Mathematics concepts, principles or strategies within the context of authentic tasks (tasks designed to determine if learners have learnt what the teacher intended them to learn) during normal learning activities. Teacher informs learners about what they have or have not achieved (i.e. whether their responses are correct or incorrect). Teacher does not use this information to identify learners' misconceptions and provide them with information about what they must do to improve their learning. 4 = Teacher assesses whether learners have learnt the Mathematics concepts, principles or strategies within the context of authentic tasks during normal												

learning activities. Teacher informs learners about what they have\have not achieved (i.e. whether their responses are correct or incorrect). Teacher uses this information to identify misconception and inform learners about what they must do to improve their learning. Teacher does not use learners' insights to develop their learning further.

5 = Teachers assess whether learners have learnt the Mathematics concepts, principles or strategies within the context of authentic tasks during normal learning activities. Teacher uses this information to inform learners about what they have achieved and to identify misconceptions and inform them about what they must do to improve their learning. Teacher uses learners' own insights to develop their learning further.

Analysis

All twelve teachers assessed whether learners had learnt the Maths concepts, principles or strategies within the context of tasks during normal learning activities. Three teachers mismanaged the assessment, and were given a rating of 2. For example, Teacher 9 instructed learners to 'build' whole numbers using Flard/number cards. Instead of using $700 + 10 + 2$ to build the number 712 the learners used separate cards of 7 (units), 1 (unit) and 2 (units). The teacher did not address this misconception_s for example, by using a number line, or using number cards to demonstrate the relationship between the value of the digits and their place in whole numbers.

Teacher 10 was teaching learners basic calculator skills. However, the teacher mismatched the activity with the concepts, principles and strategies to be taught. A number of learners in her class were confused by the unfamiliar context of the crossword puzzle (see Appendix P).

The teacher had to focus her attention on addressing learners' misconceptions about how to complete crossword puzzles, rather than on assessing whether the learners had managed to achieve the Mathematical outcome and were able use a calculator to do basic operations.

Six teachers informed learners about what they had or had not achieved (i.e. whether their responses were correct or incorrect) but did not use this information to identify learners' misconceptions and tell them what they needed to do to improve their learning. These teachers tended to focus on correcting procedural issues rather than on addressing learners' misconceptions. They were given a rating of three.

For example, Teacher 6 showed learners a card with 3 even rows of 6 'balls' each (i.e. a total of 18 balls) drawn on it and asked them how else they could write the number sentence $3 + 3 + 3 + 3 + 3 + 3 + 18$. One of the learners answered "8 + 10". The teacher responded by saying, 'There is no 8.' She did not address the learner's misconception by making it clear that they were required to change the repeated addition number sentence into a multiplication number sentence by using groups of the same numbers or of horizontal/vertical columns of 'balls'. In other words, the teacher did not explain that a more efficient way of writing this

repeated addition number sentence was to write it as a multiplication sentence.

Teacher 8 focused on improving learners' understanding of Maths procedures. For example, when learners made the following error:

$$\begin{array}{r} 978 \\ -569 \\ \hline 411 \end{array}$$

(in other words, the learners subtracted 8 from 9 instead of 9 from 8), the teacher did not appear to recognise that learners had no conceptual base for what they were expected to do. She responded by telling learners that, 'if they have 8 oranges, they can't take away 9 oranges'. They must borrow 1 from 7 so that $18 - 9 = 9$. Some of the learners lacked the skills to calculate mentally and used their fingers to try to calculate $18 - 9$. This lengthy method of computing meant that they were not able to pay attention to/follow the teachers' reasoning. The teacher did not assist learners to calculate mentally or to estimate. In another example, learners made the following error:

$$204+3+21$$

Learners' work

H	T	U
2	0	4
	3	2

Teacher 8 responded by saying, 'You mustn't place numbers next to other numbers. Each number has its own place.' She did not focus learners' attention on the relationship between the value of the digits and their position in whole numbers.

The learners in Teacher 12's class made the following error when placing digits for the following whole numbers:

$$\begin{array}{r} 1234 \\ 88 \\ 194 \end{array}$$

Th	H	T	U
1	2	3	4
	1	8	8
		9	4

She addressed the learners' error by focusing on the procedure of placing the digits in the 'correct' columns rather than on the relationship between the value of the digits and their position in whole numbers.

Three of the teachers were given a rating of 4 for using learners' responses to identify misconceptions and to inform learners about what they must do to improve their learning. For example, in Teacher 5's class a learner was asked to demonstrate how he would complete the following sum that the teacher had written on the board:

$$87 + 63$$

The teacher said, 'Let's try to estimate before you add up.' Another learner then provided an estimate of 150. After the learner at the board had added the two figures, the teacher asked him to explain how he had done his calculation. The learner explained saying, 'I added the units 7 + 3 and the answer was 10. I placed 10 aside and wrote zero under the units then added up the tens where I said 8 + 1 is 9 and 9 + 6 is 15. So I put 15 under the tens. The 1 is in under hundreds and the 5 is under 10s.' The learner's work looked like this:

$$87 + 63 \quad 150$$

The teacher warned him to 'be careful that the 5 goes straight under the 10s and that the 1 goes in the place where you are supposed to have 100s. The teacher then altered the figures so that the place values were clearer. He affirmed the learner's approach by saying, 'He looked carefully at the numbers and what they represent. How the 3 represents units and the 7 represents units. He has been able to place the numbers according to their place values and he came up with the right answer. He has done what we expected him to do. When you are going to add you must look at how many digits you have in a number.'

Teachers who addressed learners' misconceptions used learners' incorrect answers to do so. Once learners got the right answers, teachers assumed that they understood the concepts, principles or strategies being taught. When teachers realised that some learners were not understanding or were having difficulties, the whole class (even learners who had demonstrated mastery) went over the work together. Learners who were coping and who had completed the activities were not encouraged to continue on their own or given the option of continuing with additional activities. This meant that the 'pace' and direction of lessons tended to be determined to a large extent by the weakest learners in the class. For example, teachers did not proceed to more complex procedures of subtraction until all or most of the learners in the class had mastered the more basic procedures of addition. The results were that:

- a) teachers' expectations of the class as a whole seemed fairly low;
- b) teachers spent more time on certain topics/subtopics (for example, place value and addition and subtraction) than they originally planned; and
- c) teachers were unable to cover the intended curriculum.

None of the teachers used learners' own insights to develop learners' learning further. Neither did any of the teachers use learners' own insights to introduce more complex concepts, strategies or principles

6.2.2.4 Summary of the rating and ranking of teachers' practices in terms of the seven criterion used for the study

Table 17 provides a summary of fieldworkers' ratings of teachers' practices in terms of

- each of the criterion used in the study, and
- the combined total rating allocated for all the criteria.

Table 17 also provides the ranking of teachers' practices according to , fieldworkers' overall assessment of teachers' practices, (Ranking the teachers according to the criteria used for the study entailed using the combined ratings allocated to each teacher for each of the criterion).

TABLE 17: FIELDWORKERS' OVERALL RATING AND RANKING OF TEACHERS' PRACTICES IN TERMS OF THE CRITERIA

Teacher	Criterion							Total	Ranking
	1	2	3	4	5	6	7		
1	2	2	4	3	4	1	3	19	7
2	2	4	4	3	3	2	3	21	6
3	4	5	4	1	4	4	3	25	3
4	4	5	4	1	4	4	4	26	2
5	5	5	5	1	4	4	4	28	1
6	3	4	4	1	4	4	3	23	5
7	2	1	3	1	2	2	2	13	12
8	4	2	2	1	2	4	3	18	8
9	4	2	1	3	3	2	2	17	9.5 *
10	3	2	1	1	3	5	2	17	9.5 *
11	4	4	4	3	3	2	4	24	4
12	3	2	2	1	2	2	3	15	11

List of criteria

- 1 = Does the teacher engage learners in discourse about the Mathematics concepts, principles or strategies to be learnt?
- 2 = Does the teacher explain the Mathematics concepts, principles or strategies to be learnt?
- 3= Does the teacher demonstrate how the Mathematics concepts, principles or strategies to be learnt work?
- 4 = Does the teacher provide learners with opportunities to participate in practising using the Mathematics concepts, principles or strategies to be learnt?
- 5 = Does the teacher structure Mathematics activities through which learners experiment with using the Mathematics concepts, principles or strategies to be learnt?
- 6 = Does the teacher organise learner-learner discussion about the Mathematics concepts, principles or strategies to be learnt?
- 7 = Does the teacher assess whether learners have learnt the Mathematics concepts, principles or strategies the teacher intended to teach?

* These two teachers share this ranking

Ranking and rating teachers' practices according to fieldworkers' overall assessment of teachers' practices ensured that data on the implemented

curriculum was amenable to statistical data analysis. The quantitative aspects of the analysis make it possible to explore relationships between differences and similarities in teachers' instructional practices and differences or similarities in learner attainment in the Grade 4 Mathematics classes.

6.2.3 Learner interest and involvement

This section reports on the level of learner interest and involvement in the lessons.

Fieldworkers' reports on learner interest and involvement at the levels required during the lessons observed indicated that at least 75% of learners:

- in all twelve lessons appeared to be able to engage with the Maths language/ discourse,
- in all lessons appeared attentive and interested in the explanations, and in the demonstrations provided by the teachers. (Teacher 7 did not provide learners with an explanation, and Teacher 10 did not demonstrate the concepts, principles or strategies to be learnt);
- in four lessons appeared able to engage in learner-learner discussion. (Only four of the twelve teachers provided learners with the opportunity to engage in learner-learner discussion);
- in eleven classes appeared to be able to engage in practising using the Maths concepts, principles and strategies. In one lesson (Teacher 8), at least 50% of the learners appeared unable to engage in practising;
- in seven lessons appeared to be able to engage with activities/ exercises. In three lessons (Teacher 8, 10 and 12's lessons) at least 50% of the learners appeared unable to engage with the activities (Teacher 1 did not provide learners with opportunities to experiment with activities); and,
- in all lessons appeared attentive and interested in the assessment provided by the teachers.

These observations suggest that learners at the Grade 4 level are motivated to learn. However, they also support the notion that:

- teachers' expectations of learners as a whole are fairly low; and that
- some learners lack foundational competencies in Mathematics.

6.3 Summary

The main purpose of the study of the implemented curriculum was to use the criteria and indicators on the observation schedules as a tool for gauging the gel at which teachers were able to engage learners with the Maths concepts and processes to be learnt. The secondary purpose of the study of the implemented curriculum was to provide a description of the:

- extent of coverage of the topics/subtopics as outlined in the intended curriculum;
- teaching strategies employed by teachers; and
- level of learner participation in the lessons.

Data on the extent of coverage of the topics/subtopics revealed differences in the topics/subtopics covered by the teachers; and differences in the emphasis given to the topics. Data on the teaching strategies employed by the teachers revealed considerable variation in the strategies used. For example, there were differences in the use of the languages for teaching and learning, and on the textbooks and other resource materials used.

The data also revealed some of the strategies that were most frequently employed by the teachers. For example, eleven of the twelve teachers used whole class teaching to introduce, explain and/or demonstrate. None of the teachers grouped their learners according to ability. Most of the teachers used textbooks either to plan their lessons, or as sources for exercises in their lessons.

Data on the level of learner participation in the lessons indicated that the majority of learners appeared interested and attentive. At least half of the learners in all classes appeared able to engage in the lesson at the levels required.

Data on the level at which teachers were able to engage learners with the Maths concepts and processes to be learnt provided evidence of:

- teachers themselves introducing incorrect forms of technical or Mathematical terms;
- variation in terms of the levels at which teachers covered the topics/subtopics;
- teachers not addressing topics/subtopics in terms of increasing difficulty;
- teachers experiencing difficulty in engaging learners with Maths concepts and processes to a significant depth,
- teachers focusing on those aspects of the Maths concepts and processes that learners found easiest (for example, procedural issues such as arranging digits in the correct 'place' , or basic operations such as addition and subtraction);
- teachers not proceeding to more complex procedures until all learners had mastered more basic procedures so that the pace and direction of lessons tended to be determined to a large extent by the weakest learners in the class;
- teachers not addressing, or experiencing difficulty emphasising more complex procedures (such as multiplication and division) and processes (such as problem-solving strategies, estimation, etc.); and,
- superficial coverage of Maths concepts and processes in lessons where teachers used real-life/everyday experiences as a context for teaching and learning.

The study of the implemented curriculum also revealed that:

- a number of learners lacked foundational Mathematical skills (such as skills in mental arithmetic) and basic conceptual understandings (such as an understanding of how the number system works);
- learners were given few opportunities to practice using increasingly complex examples that assisted them to develop their understanding and use of Maths concepts and processes in progressively difficult ways,

- learners were not given opportunities to read, understand and use information or language provided in Maths texts, for example through translating word problem questions into number sentences;
- learners spent a large proportion of time practising work that they would/should have covered in the Foundation/Junior Primary Phase;
- learners in each of the classes all completed the same exercises/activities, learners who were coping and completed exercises/activities were not given the option of continuing with additional activities;
- what learners were expected to do with the Maths content (concepts and processes) being taught was not cognitively demanding;
- learners were given few opportunities to discuss Mathematical concepts and/or processes, express their line of reasoning, or justify their thinking;
- learners' responses to activities or exercises almost always took the form of numbers or numbers and Maths notation; and,
- learners were given few opportunities to apply Mathematical concepts, strategies or principles to real-life problems.

In particular, the study of the implemented curriculum provided evidence of:

- teachers being unable to address Mathematical processes such as problem-solving strategies, estimation, etc., or more complex procedures such as division and multiplication because learners lacked basic skills and conceptual understandings in Math;
- teachers introducing incorrect forms of technical or Mathematical terms because of confusion between teachers' and learners' primary language, the language of learning and the language of Mathematics;
- teachers experiencing difficulty in engaging learners with Maths concepts and processes to a significant depth because they did not understand the concepts and processes themselves,
- teachers using textbooks as a source for exercises for lessons and, in some cases, to plan their lessons, but using textbooks in random, ad hoc ways that did not assist learners to:
 - a) develop or practice using Maths concepts and processes in terms of incremental complexity; and
 - b) read, understand and use texts provided in Maths textbooks.

So as to ensure that data on the implemented curriculum would be amenable to statistical data analysis, teachers' practices have been rated and ranked according to the fieldworkers' overall assessment in terms of all the criteria. This quantitative aspect of the analysis allowed for the possibility of exploring the relationships between differences and similarities in teachers' instructional practices, and learner attainment in the item tests.

7. ASSESSING THE ATTAINED CURRICULUM

An integral part of this study was the assessment of the attained curriculum. By assessing the attained curriculum the researchers hoped to reflect back to the intended curriculum and to signal some of the indicators of effective teaching in the implemented curriculum.

In order to assess the attained curriculum the assessment needed to:

- have external Mathematical validity. In other words the test needed to represent the Mathematical knowledge and processes that are generally accepted to be an appropriate standard for learners at the grade 4 level;
- match the curriculum that the teachers intended covering over the period of the study;
- be sensitive to changes in learners' understanding; and
- be possible to be administered effectively and efficiently.

Selected TIMSS test items from Population 1 were used for the study because the tests:

- were directed at those two adjacent grades which included the most nine-year olds. In most countries this coincided with the third and fourth year of schooling. In South Africa these are Grades 3 and 4;
- were developed through international consensus involving input from Mathematics specialists in the 26 participating countries. Every effort was made to ensure that the test items were reflective of current thinking and priorities within the field of Mathematics, and were not biased in favour of any one country (Martin, M. et al, 1996).
- included a content and a performance expectation aspect, that describes the range of knowledge and skills expected of learners in school Mathematics. They also included a range of difficulty levels reflected by the International Difficulty Index (see page 79);
- matched the content areas and the performance expectations of the intended curriculum that teachers reported they would be covering during the first term of Grade 4; and
- included both multiple choice and free-response items. (18 Items were of the multiple choice format, while 6 items (one of two parts) were free-response items.)⁸.

The researchers hoped that this test:

- would reflect improvement in Maths achievement over the first term; and
- provide an indication of the Mathematical ability of grade 4 learners.

However, the researchers were also aware that group testing of this nature, in particular pencil and paper tests, could have disadvantages in that.

- while the content may match the curriculum, the format may be unfamiliar to learners,
- the language component could introduce a difficulty at this level;

⁸ The multiple choice format was unfamiliar to most of the learners. However, it was hoped that, as English second language learners, the sample of learners would find it easier to recognise which of the available options was correct, than they would to create their own answers.

- the reading level required to solve some Mathematical problems might disadvantage some learners (for example, some of the items, especially those involving the problem solving aspect required more reading), and
- the motivation on the part of all the learners to attempt all the items may be low, and they may give up prematurely.

Thus.

- care was taken to introduce pupils to the format of the test, both the multiple choice and the free-response format;
- the tests were provided in both English and Xhosa in order to eliminate the difficulty of reading a second language⁹;
- extra time was given to accommodate for slow reading, (i.e. 45 minutes as opposed to the 25 minutes that were recommended in the TIMSS test); and
- during the tests the fieldworkers encouraged learners to at least attempt every item.

7.1 The Attained Curriculum

The attained curriculum was assessed in terms of evidence of growth (if any) in learner achievement (see 7.1.1) and attitudes (see 7.1.2) in the twelve grade 4 classes tested.

7.1.1 Learner achievement

Learner achievement in the item tests is analysed in terms of: • Pre- and post test results (7.1.1.1);

- a comparison of learners' post-test results with International averages in the TIMSS (7.1.1.2); and
- an analysis of learner response patterns linked to different content areas (7.1.1.3).

7.1.1.1 Pre- and post-test results

The pre-test scores formed the baseline for growth in learner achievement.

Table 18 which follows provides data on learners' pre-test mean percentage scores across the twelve classes.

Pre-test scores

TABLE 18: PRE-TEST MEAN PERCENTAGE SCORES FOR THE 12 TEACHERS' CLASSES

1	2	3	4	5	6	7	8	9	10	11*	12	Overall %
7.8	12,7	10,7	16.1	11.4	14,8	7,7	11,1	10,7	6,1	34,0 *	14,0	11,2

* There was some problem with the pre-testing in this teacher's class. In the light of the post-test result, this result was treated as aberrant data.

⁹ Some Mathematics terminology may be more familiar in English than in the vernacular language, and this approach may have disadvantaged learners. This is an area for future research

Comment

The pre-test scores were far below the averages of the 26 countries, which participated in the TIMSS study as is indicated by the average scores on individual items. While there is no direct comparison as the Focus on Four study used only a sample of the items, a comparison with international averages can be deduced from the following. The average percentage correct for the Mathematics content area of whole numbers of which we included 16 items was 67% at the upper level (Grade 4) and 54% at the lower level (Grade 3). The country with the lowest score at the lower level was Iceland with 37%, and at the upper level Kuwait 36%. The country, which had the highest scores at both levels was Korea with 81% and 88% respectively.

The fact that these scores were so low, meant that these tests were not entirely appropriate for our study which attempted to correlate learner attainment with the implemented curriculum as was evidenced in classroom practice. Nevertheless we were able to extract some very useful and interesting findings, through an analysis of the results on individual items, that point to areas for future research.

The reasons for these low scores may be due to

- the fact that the implemented curriculum covered in the Foundation Phase did not cover the basic knowledge required for the test,
 - a mismatch between informal Mathematics required of some learners in the classroom and the formal "school" Mathematics required in TIMSS tests¹⁰;
 - the low reading levels of many learners. Learners may only ever engage with the Mathematical ideas at a very superficial level, which means that they are unable to apply their knowledge in new situations.
- Pre-test and Post-test scores

The researchers looked for evidence of gain in learner achievement through a comparison of the pre- and post-test results

1. in classes as a whole; and
2. of the learners as a whole in individual items.

We also compared the learners' results in individual items with the international averages for each item.

The following table provides data on the pre- and post-test scores for each class and the difference between the pre-and post-test mean.

¹⁰ Do learners 'catch up'? Not if the TIMSS results for Grade 7 are anything to go by. At Population 2 (Grade 7 and 8, standards 5 and 6) South Africa achieved well below the International average

TABLE 19: PRE-TEST AND POST-TEST SCORES OF EACH CLASS

Teacher	Pre-test mean	Post-test mean	Difference
1	7.8	12.0	4.2
2	12.7	14.1	1.4
3	10.7	14.0	3.3
4	16.1	17.8	1.8
5	11.4	12.8	1.5
6	14.8	16.5	1.7
7	7.7	10.5	2.7
8	11.0	14.0	3.0
9	10.7	12.5	1.7
10	6.1	12.5	6.4
12	14.0	15.1	1.2
	123.1	152.0	
	11.2	13.8	2.6
*11	33.9	16.7	-17.2

* Data on teacher 11's class was treated as aberrant data.

For data on the performance of all learners in each class on individual items in the pre- and post tests see Appendix Q.

The table which follows provides data on the performance of all learners in each class on individual items in the pre- and post tests as a whole summarised in average scores for the whole class.

TABLE 20: LEARNERS' PRE- AND POST-TEST RESULTS ON INDIVIDUAL ITEMS

Items	Comparison of Pre-test and Post test scores without teacher 11		
	Pre-test scores %	Post-test scores %	Difference
I3	21.7	18.8	-2.9
I4	33.7	19.5	-14.2
I7	8.2	9.6	1.4
I9	16.4	17.8	1.4
J4	11.1	5.8	-5.3
J5	9.2	11.6	2.4
J8	14.2	18.3	4.1
J9	26.7	32	5.3
K2	12.0	11.3	-0.7
K3	12.0	23.9	11.9
K6	21.9	26.7	4.8
L2	5.8	11.6	5.8
L4	13.5	24.1	10.6
L7	13.3	19.8	6.5
M3	11.1	15.4	4.3
M6	14.2	17.3	3.1
M8	18.6	24.6	6
M9	7.5	18.1	10.6
S2	0.0	1	1
T2	0.5	0	-0.5
U5	7.0	16.9	9.9
V2	0.0	0	0
V3	0.0	0	0
V4A	1.4	2.7	1.3
V4B	0.2	0	-0.2
Mean %	11.208	13.872	2.664

7.1.1.2 A comparison of learners post test results with International Averages in TIMMS

Tables 21-22 provide a comparison of post-test scores on individual items with the International averages for each item in terms of:

- a) multiple choice items (Table 21); and
- b) free-response items (Table 22).

TABLE 21: COMPARISON OF MULTIPLE CHOICE ITEM RESULTS OF 12 CLASSES WITH INTERNATIONAL AVERAGES

Item	Content categories	Focus on Four scores* Rounded off to whole numbers	International Average % of learners' responding correctly Lower Grade *	International Average % of learners' responding correctly Upper Grade *
I3 Which number is it?	W	18%	46%	57%
I4 What is 3 times 23?	W	20%	74%	84%
I7 Number sentence for pages remaining	P	9%	49%	62%
I9 Subtraction of four-digit numbers	W	18%	50%	71%
J4 What is the increase in product?	W	6%	30%	45%
J5 Operation to get from A to B	P	12%	27%	39%
J8 Which is the best estimate of hours?	E	18%	33%	52%
J9 Number in box	W	32%	64%	73%
K2 Addition of four-digit numbers	W	12%	67%	84%
K3 Multiply by five	W	24%	37%	53%
K6 Pattern of tiles	P	28%	53%	63%
L2 Chance of picking red marble	D	13%	40%	51%
L4 Shapes in a pattern	P	24%	61%	72%
L7 Which pair different by 100?	W	20%	33%	49%
M3 Equivalent operation	W	17%	53%	63%
M6 What to do to correct mistake?	W	18%	57%	70%
M8 Choose largest number	W	25%	76%	86%
M9 Make number sentence true	P	19%	55%	70%

* TIMSS tested at the two grades, which included most 9 year-olds. The lower grade was usually Grade 3 while the upper grade was Grade 4.

Code for content categories W = whole numbers P = patterns, relations and functions D = data representation, analysis, probability E = estimation, measurement and number sense.

TABLE 22: COMPARISON OF FREE-RESPONSE ITEM RESULTS OF 12 CLASSES WITH INTERNATIONAL AVERAGES

Item	Content categories	Focus on Four scores* Rounded off to whole numbers	International Average % of learners' responding correctly Lower Grade *	International Average % of learners' responding correctly Upper Grade *
S2 Complete number sentence	W	1%	44%	63%
T2 Make smallest whole number	W	0%	29%	43%
U5 Addition / multiplication task	W	17%	63%	77%
V2 Number 1000 more than 56821	W	0%	30%	48%
V3 What is 5 less than 203?	W	0%	48%	62%
V4A Game with cards. Who won?	W	3%	16%	24%
V4B Game with cards. Winning numbers.	W	0%	31%	48%

Code for content categories
W = whole numbers
P = patterns, relations and functions
D = data representation, analysis, probability
E = estimation, measurement and number sense.

Comment:

A comparison of post-test results with the International Averages is interesting. The International results provide a reference point from which to gauge our results. 60% of the lower grade in the International sample and 80% of the upper grade achieved the correct answers to items 14, K2 and M8. Less than 25% of our sample achieved the correct answer.

Except for U5 the learners' response to free-response items was negligible. We had hoped to be able to code learners' responses in order to analyse errors. Some learners, between 12% and 25% may be able to select a correct answer when given the correct answer as well as some distractors, but only between 1% and 3% are able to write down the correct answers.

7.1.1.3 Analysis of Learner Response Patterns

It was hoped that TIMSS coding rubrics would enable the Focus on Four researchers to analyse learners' responses in ways that would provide information about the procedures used by the sample of Grade 4 learners to solve Mathematical problems. However learners' responses to the free response items, with the exception of Item U5, were so poor that this was not possible. The multiple choice items elicited better responses from the learners than the free-response items. This suggests that receptive Mathematical language, precedes expressive language, and that overall

learners found it easier to recognise correct responses rather than 'create' their own answers.

An analysis of learner response patterns (evidence of trends across all twelve classes in learners' responses) in the multiple choice items was conducted by calculating:

a) the percentage of correct responses to each item so as to identify the items with the highest percentage of correct answers overall in the multiple choice items in the post-tests (see Appendix R), and

b) calculating the percentage of different types of incorrect responses to selected multiple choice items linked to the different content areas so as to identify possible commonly held misconceptions (see Appendix S).

The following table provides data on the seven items with the highest percentage of correct answers in the post-tests.

TABLE 23: TEST ITEMS WITH THE HIGHEST PERCENTAGE OF CORRECT ANSWERS OVERALL IN THE POST-TESTS

Item	Description	% correct responses in Focus on Four sample	International Average Percent	
			Lower Grade	Upper Grade
J9	Number in box	32,1%	64%	73%
K6	Pattern of tiles	27,5%	63%	63%
M8	Choose largest number	25,4%	76%	86%
L4	Shapes in a pattern	24,6%	61%	72%
K3	Multiply by 5	24,6%	37%	53%
I4	What is 3 times 23?	21,4%	37%	53%
L7	Which pair is different by 100?	19,4%	33%	49%

Comment

The seven test items, which scored the highest, fall into two content categories, Whole Numbers (J9, M8, 14 and L7) and Patterns, Relations and Functions (K6, L4, K3). It would appear that because the test was too difficult, the possibility of blind guessing would annul any comments on learners' responses. However, if this were the case, one would expect 25% or a margin of 6% on either side of this. In some cases, the largest choice was over 40%, which indicates conscious choice. However, these comments remain tentative and are in need of further verification.

The following is an analysis of learners' response patterns linked to the different content areas.

Whole numbers

The category of whole numbers included understanding place value up to thousands, ordering and comparing numbers, and solving single-step as well as multiple-step problems and involved the operations of addition,

subtraction, multiplication and division (Mullis et al, 1997). For example, in Item J-9 below:

J9. Here is part of a wall chart that lists numbers from 1 to 100.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25					

Below is part of the same wall chart. What number should be in the box with the question mark inside?

43	
53	
	?

A. 34
B. 44
C. 54
D. 64

familiarity with the 100-chart and an understanding of how our number system is built up would have enabled learners to make the right choice. Alternatively the ability to establish the horizontal and vertical pattern evident in the first two lines could have evoked a correct choice. Both these requirements would necessarily have required some understanding of place value and how consecutive numbers are constructed.

Unfamiliarity with a number chart, no understanding of the number values of written two-digit numbers, and an inability to understand the relationship between the two parts of the question may have caused difficulty with this item.

While 32,2 % of the sample got the correct answer 64, it is of interest that the next most frequent (19,5%) answer was 54. This indicates that learners could have relied on knowledge of consecutive numbers (i.e. after 53 comes 54, with no reference to the horizontal or vertical axis).

In Item M8 learners were required to choose the largest number out of four four-digit numbers.

M8. Which of these is the largest number?
A. 2735
B. 2737
C. 2573
D. 2753

The numbers differ in the third, second or first place values. The item is designed to test the learners' understanding of place value (Mullis I et al, 1997:64.) The task involved interpreting the meaning (value) of each number and then comparing the values with each other. This item fell within the Performance Category, Using Complex Procedures.

While this item ranked third in terms of number of correct responses (25,5%), the largest percentage of learners (40,3%) chose 2537. It would appear that in this case learners looked only at the unit column. The next largest percentage (27,2 %) chose 2573. It appears that in this case they may only have looked at the tens column.

Item 14 tests learner's understanding of multiplication.

I4. What is 3 times 23?
A. 323
B. 233
C. 69
D. 26

In order to get the correct answer the learner had to understand the value of the digits in the number 23, and then apply the operation of multiplication, or repeated addition. In some cases $23 + 23 + 23$ (repeated addition) was recorded and in other cases as $/////// (23 + 23 + 23 \text{ times})$ was evident as "working out".

21,5 % of the sample selected the correct option, 69. However, 18,8 % of the learners selected 26 which may indicate no understanding of the multiplication symbol. 15,2% and 23,3% of learners respectively chose A. 323 and B. 233, and 21,2 % left this item out completely.

In the International Test this item was answered correctly by 74% at the Lower Grade and 84% at the Upper Grade level. Evidently the majority of learners had mastered this level of multiplication by grade 4, albeit at a later stage in the year.

Item L7 again addresses the meaning of numbers.

<p>L7. In which pair of numbers is the second number 100 more than the first number?</p> <p>A. 199 and 209</p> <p>B. 4236 and 4246</p> <p>C. 9635 and 9735</p> <p>D. 51 863 and 52 863</p>

This item is also designed to test learner's understanding of the number system, more specifically place value. Learners would have had to understand the value of each of the pairs and then compare them to ascertain the difference. This item was categorised as Using Complex Procedures in the Performance Expectation category.

While this item ranked seventh in terms of frequency of correct responses less than a fifth (19,5%) chose the correct answer. 26,3% chose D (51 863 and 52 8630). This could be seen as confusing hundreds and thousands. A further 22,5% chose A which could be because the learners took into account only the hundreds digit and ignored the other digits.

The International Averages of learners responding correctly to this item was 33% in the Lower Grade and 49% in the Upper Grade. This bears closer analysis, as this item proved to be generally difficult for all learners in the 26 participating countries.

Patterns, Relations and Functions

Item K6 involved recognising a geometric pattern.

K6. Here is the beginning of a pattern of tiles

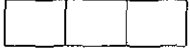


Figure 1




Figure 2

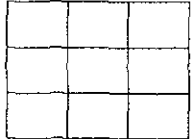


Figure 3

If this pattern continues, how many tiles will be in Figure 6?

- A. 12
- B. 15
- C. 18
- D. 21

Finding the solution to this problem involved either reconstructing the pattern through drawing or visualisation, or recognising the numeric sequence. While 27,5% of the learners got this correct, (18 tiles would be in Figure 6), 28,9% chose 21 tiles. This could be because learners had the right idea, but did not count up correctly in 3's. 20,8% of the learners misread the question and gave the response, 12, which would continue the pattern to Figure 4 (rather than Figure 6).

Item L4 shows shapes arranged in a horizontal pattern.

L4. These shapes are arranged in a pattern.

○▲○○▲▲○○○▲▲▲

Which set of shapes is arranged in the same pattern?

- A. ★□★□★□□★□□
- B. □★□□★□□□★□□□□
- C. ★□★□□★□□□
- D. □□★□★□□★□□★

The learner is required to choose the identical horizontal pattern from four patterns. While 24,6% of the learners selected the correct option, 30,9% of the sample chose the option, B, which was identical in terms of the first three elements of the pattern, but differed after that.

This suggests lack of the problem-solving skill, which requires that possible options be tested.

Item K3 looks at the relationship between two numbers and requires some understanding of Mathematical notation, particularly the use of the arrow.

K3. Which pair of numbers follows the rule "Multiply the first number by 5 to get the second number"?

A. $15 \rightarrow 3$

B. $6 \rightarrow 11$

C. $11 \rightarrow 6$

D. $3 \rightarrow 15$

The most common response (25,7%) was A, (i.e. $15 \rightarrow 3$), which suggests that learners misinterpreted the language and selected the option which involved division, the inverse of what they were required to do.

Analysis of learners' response patterns by calculating different types of incorrect responses to selected multiple choice items linked to the different content areas

An examination of the different types of incorrect responses to selected multiple choice items linked to the different content areas provide interesting pointers to possible problems in the teaching and learning of Mathematics at this level.

Whole numbers

Two other items, which have at their core an understanding of place value, are Item K2 and Item 19:

Item K2 requires learners to

Add:	6971
	+5291

and provides learners with the following options to choose from:

- A. 11 162
- B. 12 162
- C. 12 262
- D. 1 211 162

Each of the above answers except C (the correct answer) may be derived by means of a logical, but incorrect, process based on an incomplete understanding of place value. In A, the adding is correct but the process of "carrying" numbers has been left out. Option B has left out one instance of carrying. Option D has incorporated all the numbers without regard to their place value.

Option D was chosen by 45,5% of learners, while the other two options A and B (both of which required a some understanding of place value) were selected by 13,6% and 15,9% of the learners, respectively. The correct option C was the option chosen by 12,5% of learners. Option D indicates the poorest understanding of the algorithm, and little understanding of number meaning.

Item 19 was a subtraction problem, which required decomposition and regrouping.

The learners were asked to: Subtract: 6000
-2369

The options included:

- A. 4369
- B. 3742
- C. 3631
- D. 3531

To get the answer A (4369) learners subtracted the smaller digit from the bigger digit in each column. This is a misconception, which follows from subtraction of one digit numbers, where learners have been told that "subtraction is taking away the smaller from the bigger". Option A was selected by 31 % of the learners. 18, % scored the correct answer, C¹¹.

Item J4, 25×18 is more than 24×18 . How much more?, which tests understanding of an increase in product proved to be one of the hardest TIMSS items administered internationally.

The options provided include:

- A. 1
- B. 18
- C. 24
- D. 25

¹¹ It is of some interest that the international scores on these items ranged from 88% (Korea) to 9% (Norway) at the grade 3 level. It is also somewhat heartening to note that from the grade 3 level to the grade 4 level, Norway improved from 9% to 60%, and England improved from 23% to 36% (Mullis, 1997: 68).

The correct answer to this item, B (18) was chosen by 6,7% of learners. 15,2% of the learners did not answer. 51,5 % selected option D. This suggests a lack of understanding of this Mathematical statement.

At an elementary level the Mathematical sentence 4×5 can be understood as 4 groups of 5, and 5×4 as 5 groups of 4. However in Primary schools across the Western Cape, the researchers have observed the Mathematical statement 4×5 interpreted as 4 taken 5 times. Whether one or other convention is adopted is really of no consequence, the crucial concept is the grouping of numbers.

In the light of this 25×18 can be represented as 25 groups each of 18.
18 18 18 18 18 18 18 18 18 18 18 18

18 18 18 18 18 18 18 18 18 18 18 18

24 groups each of 18 would imply one less group of 18, therefore 18 less.

18 18 18 18 18 18 18 18 18 18 18 18

18 18 18 18 18 18 18 18 18 18 18 18

If one took the other interpretation, (i.e.25 taken 18 times), this could be represented as 18 groups of 25 in each group.

25 25 25 25 25 25 25 25 25

25 25 25 25 25 25 25 25 25

Taking this line of reasoning 24×18 would be 18 groups of

24. 24 24 24 24 24 24 24 24 24

24 24 24 24 24 24 24 24 24

In this case each of the 18 groups has one less (24 rather than 25), making 18 less in total.

Probability, Estimation and Number sense

Besides whole number and patterns; one probability item and one item which involved estimation were included in the test. In the probability item (L2), learners were required to choose the bag of marbles, which had the greatest chance of getting a red marble. The three bags had ten, 100 and 1000 white marbles with only one red marble in each. 14,1% of the learners chose the correct option (10). 50,2 % of the learners chose the bag with 1000 marbles, which indicates an inverse understanding of the concept of probability. There may also have been a language factor here. An additional factor is that probability is not included in the Western Cape junior primary syllabus, which means that learners' in all likelihood have

not been taught. However, what the item does test is the ability to solve problems of a non-routine nature.

Estimation (Item J8) in contrast to Probability, forms part of the Junior Primary syllabus.

J8. Nomsa worked 57 hours in March, 63 hours in April and 59 hours in May. Which of these is the BEST estimate of the total number of hours she worked for the three months?

A. $50 + 50 + 50$

B. $55 + 55 + 55$

C. $60 + 60 + 60$

D. $65 + 65 + 65$

However item J8 requires a specific understanding of estimation which may not be the learners' understanding of estimation. 18,5% of the learners chose the correct option (C), while 36% chose option D.

7.1.2 improvement in learners' attitude towards Maths

Improvement in learner interest in and attitudes towards Mathematics has been measured through developments in learners' interest and attitude as reflected in the questionnaires administered at the beginning and end of the first term.

Because of the findings in the field test the questionnaire was simplified. As a result the instruments were unable to capture subtle changes in learner attitudes. However the data collected on the learners' perceptions about the value of Maths and their own success in Maths was interesting. Over 80% of the learners believed that Maths was important. 75% of learners reported that they usually did well in Maths and that Maths was an easy subject. 90% reported that they enjoyed learning Maths. Over 60% of learners reported that good luck was what was needed to succeed in Maths, but over 60% of learners also reported that natural talent was what was needed to succeed in Maths. 81% reported that studying and home work and memorising the textbook were important criteria for doing well at Maths. While the reliability of this data is questionable, and no major conclusions can be drawn from the information, there may be a link between the learners' perception that Maths is easy and the overall low cognitive demands made on them in the Mathematics lessons observed. On the other hand the data indicated that learners have a positive attitude towards Mathematics.

7.2 Summary

The assessment of the attained curriculum, as evidenced through the use of the TIMSS item tests indicated that the learners:

- had little understanding of the Mathematical knowledge and skills that are integral to the intended curriculum; and
- are far behind their international counterparts in 26 countries that participated in the TIMSS.

The tests were of a difficulty level which precludes a sensitive analysis of what the learners know and are able to do. However, the findings suggest that:

- the majority of learners have limited knowledge of how the number system works past two digits; and
- the understanding of place value (Items MS and L7), and the application of this concept in standard algorithms such as addition (K2), subtraction (19) and multiplication (Item 14) is lacking in at least 75% of learners tested.

It seems that learners' problem solving abilities are severely hampered by a lack of basic understanding of how the number system is constructed and consequently how the basic operations can be used as tools for solving problems.

8. STUDYING THE RELATIONSHIP BETWEEN THE IMPLEMENTED CURRICULUM, THE INTENDED CURRICULUM, THE ATTAINED CURRICULUM, AND THE SOCIAL AND EDUCATIONAL CONTEXT FOR LEARNING AND TEACHING

Section 8 of this report provides an analysis of the relationships between the implemented curriculum, and

- ✍ the intended curriculum (see 8.1);
- ✍ the social and educational contexts for learning and teaching (see 8.2);
- ✍ the attained curriculum (see 8.3).

8.1 The relationship between the implemented curriculum and the intended curriculum

The study of the intended curriculum revealed that:

- ✍ all twelve teachers held a common intended curriculum.

The study of the implemented curriculum revealed that:

- ✍ not all of the teachers covered the same topics; and
- ✍ different teachers gave more emphasis to different topics / subtopics.

The relationship between the intended and the implemented curriculum has been analysed in terms the relationship between:

- ✍ the topics / subtopics that teachers said they intended covering, and the topics / subtopics that teachers reported actually covering by the end of the first term, and
- ✍ the estimated number of lessons in which teachers said that they would cover the topics / subtopics, and the estimated number of lessons in which they reported covering the topics / subtopics.

Figures 11-17 which follow illustrates the relationship between the topics / subtopics that teachers said they intended covering, and the topics / subtopics that they reported actually covering, as well as the estimated number of lessons in which teachers said they intended covering the topics / subtopics, and the estimated number of lessons in which they reported covering the topics / subtopics at the end of Term 1.

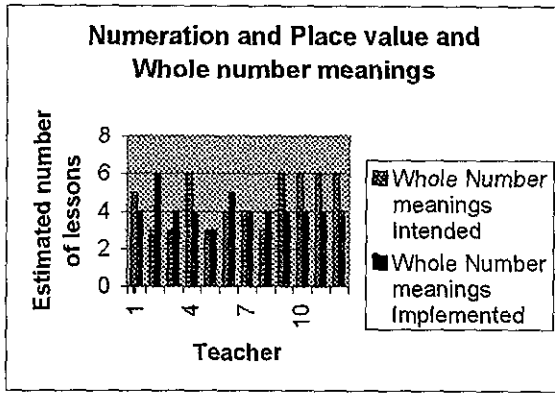


Figure 11

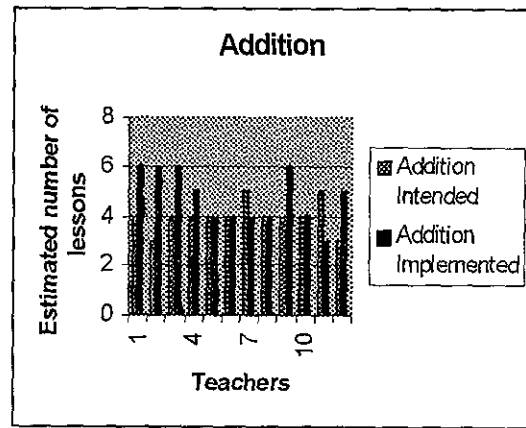


Figure 12

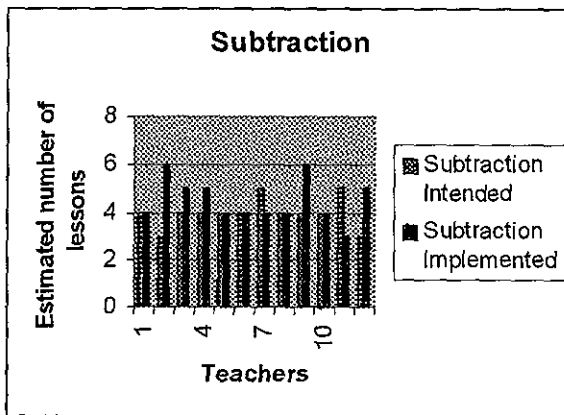


Figure 13

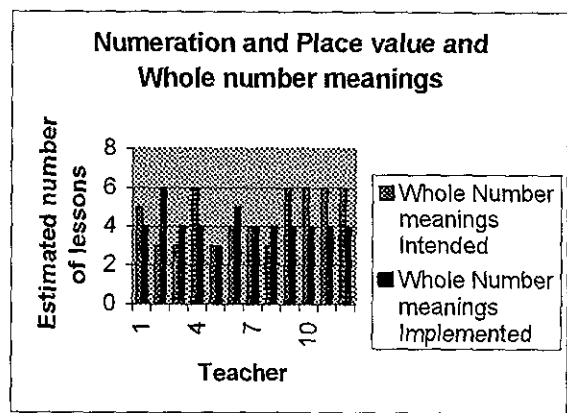


Figure 14

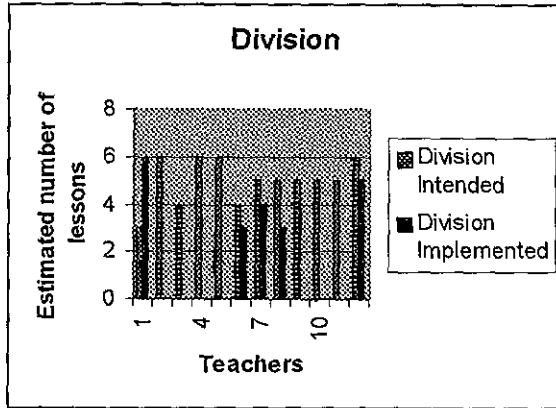


Figure 15

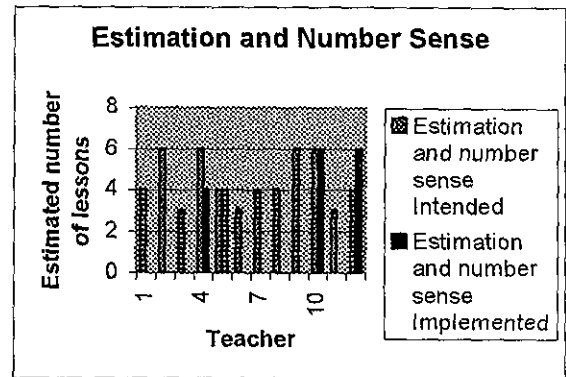


Figure 16

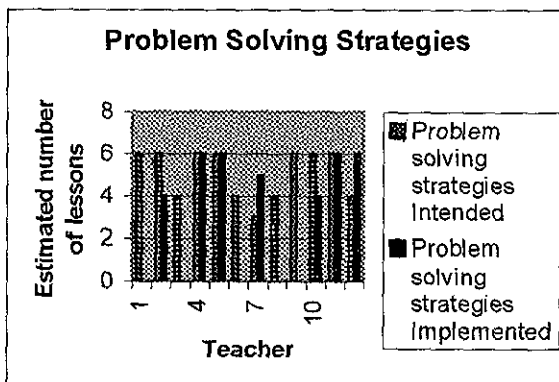


Figure 17

Key - estimated number of lessons
 0 = none
 3 = 1-5 lessons
 4 = 5-10 lessons
 5 = 11-15 lessons
 6 = > 15 lessons

The analysis of the relationship between the intended and the implemented curriculum revealed discrepancies between the intended curriculum goals as expressed by teachers (at the end of 1997 and at the beginning of 1998), and the curriculum that teachers actually implemented during the first term of 1998. In particular, the analysis revealed that some of the teachers did not address some of intended topics / subtopics at all.

This could be attributed to

- poor planning on the part of teachers;
- disruptions, or
- a low work rate at the schools.

8.2 The relationship between the implemented curriculum and the social and educational contexts

Data on the social and educational contexts for learning indicated that the sample of schools, teachers and learners form a relatively homogenous groups. However, findings revealed key school and classroom variables and/or variables in teacher backgrounds that may be related to teacher effectiveness, or that could contribute to differences in learner achievement. For example, variables in school characteristics such as the number of minutes allocated to Mathematics teaching per week; teacher characteristics such as teachers' experience, qualifications; and attendance at in-service programs, and variables in classroom characteristics such as learners' age ranges, class size, etc,

Because of the small sample of teachers used in the pilot study, no conclusive answers to the relationship between variables in teacher backgrounds (such as teachers' qualifications) and teachers' instructional practices emerged from the study. In a larger-scale study, an analysis could be conducted using a computerised rank order correlation test to measure the degree of the relationship between the ranked data on teachers' classroom practices and teachers'

- years of teaching experience;
- grades they reported teaching in the last 5 years,
- highest formal level of education;
- the year that they reported achieving their last formal qualification; and
- whether teachers reported that they were subject specialists or not.

Results could be examined for evidence of relationships between a lack of focus on Maths content, or a lower level of learner engagement with Maths concepts and processes in the lessons of teachers who were not adequately equipped to deal with teaching Maths.

Nevertheless, data on the social and educational context and the implemented curriculum supports the notion that:

- classrooms are subject to many other extraneous influences and contextual variables;
- there may be other aspects of the system that are failing; and
- the social and educational context for learning and teaching is an important unit for analysis in curriculum reform processes, teacher training, and materials development.

8.3 The relationship between the implemented curriculum and the attained curriculum

Selected items from the TIMSS tests were used to measure the attained curriculum because they:

- a) captured the topics/ subtopics (Maths content) that the teachers intended covering; and
- b) assessed formal classroom Mathematics that the sample of learners were unlikely to acquire in everyday contexts, but that needed to be mediated by the teachers; and
- c) represent international consensus on learner performance in standardised test at the Grade 4 level.

However, no statistically significant improvement in learner achievement was evident in the pre- and post-test results of individual teachers' classes through the use of the TIMSS tests. As a consequence, it was not feasible to analyse data in ways that made it possible to identify key variables that could have contributed to differences in learner achievement in the TIMSS item tests.

Nevertheless, overall learner achievement in specific items in the post-tests provided some indication of the majority of the learners' current knowledge base and experience in the Learning Area of Mathematical Literacy, Mathematics and Mathematical Sciences.

In particular, an examination of the sample of learners' responses to specific items in the post-tests suggested that most learners

- had difficulty reading and understanding the language and information provided in the TIMSS items tests, particularly in word problem questions (evident through learner achievement in items I-7, J-8, and S-2);
- were unable to work efficiently because they did not know or lacked foundational competencies in Maths, in particular, competency in mental arithmetic (recalling number bonds and times tables), (evident through learner achievement in items I-4, and J-4);
- lacked a basic understanding of the number system, in particular, an understanding of place value (evident through learner achievement in items M-8 and L-7);
- were unable to work with complex procedures and processes such as multiplication and division, and recognising and discovering patterns (evident through learner achievement in items H-5, J-9, and L-4); and
- were unable to explain or justify their answers or reasoning (evident through learners' achievement in the open-response item V-4).

Data from learners' responses in the learner questionnaire indicated that:

- the majority of learners had a positive attitude towards Math;
- 75% of the sample of Grade 4 learners believed that Maths is an easy subject and were confident about their ability to learn Maths.

The study of the implemented curriculum provided evidence of:

- teachers using textbooks as a source for exercises for lessons in random, ad hoc ways that did not assist learners to

- a) develop or practice using Maths content (concepts and processes) in terms of incremental complexity; and
 - b) read, understand and use texts provided in Maths textbooks.
- teachers introducing incorrect forms of technical or Mathematical terms because of confusion between teachers' and learners' primary language, the language of learning and the language of Mathematics;
 - teachers being unable to address Mathematical processes such as problem-solving strategies, estimation, or more complex procedures such as division and multiplication because learners lacked basic skills and conceptual understandings in Maths;
 - teachers experiencing difficulty in engaging learners with Maths concepts and processes to a significant depth because teachers themselves did not understand the concepts and processes; and
 - teachers providing few opportunities for learners to discuss Mathematical concepts and/or processes, express their line of reasoning, or justify their thinking.

An analysis of the relationship between overall learner achievement in the posttests and teachers' instructional practices suggests that teachers need to pay more attention to developing

- Maths language. For example, through teachers - providing learners with opportunities to engage with Maths texts (using materials such as textbooks as important resources for providing learners with opportunities to read, understand and use information or language provided in Maths texts); deliberately teaching carefully-defined Maths terms and definitions, making differences between learners' everyday language, the language of learning and new Maths language explicit, etc.
- learners' Mathematical communicative competence. For example, through teachers - encouraging learners to explain or justify their answers or reasoning; actively eliciting explanations from learners; using whole class discussion to elicit learners' understandings, asking learners to present their answers and thinking to the whole class; involving the whole class in deciding on the best solution/s, etc.; and
- Maths content at more appropriate levels of cognitive complexity. For example, through teachers - engaging learners in using increasingly complex examples that assist them to develop their understanding and use of Maths concepts and processes in progressively difficult ways.

8.4 Summary

No statistically significant improvement in learner achievement was evident in the pre- and post-test results of learners in individual teachers' classes. As a consequence, it was not feasible to analyse data in ways that made it possible to identify key variables that could have contributed to differences in learner achievement in TIMSS item tests.

However, an analysis of the relationship between the implemented curriculum and the intended curriculum revealed discrepancies between the intended curriculum goals as expressed by the teachers, and the curriculum that teachers actually implemented during the first term of 1998.

Because of the small sample of teachers used in the pilot study, no conclusive answers to the relationships between the implemented curriculum and the social and educational contexts for learning and teaching emerged from the study. However, the analysis supports the notion that classrooms are subject to many other extraneous influences and contextual variables, and that there may be other aspects of the system that are failing.

The relationship between the implemented curriculum and the attained curriculum has been analysed in terms of the relationship between teachers' instructional practices and learner outcomes as measured through learner achievement in TIMSS item tests, and through learner attitudes towards Mathematics as revealed in the questionnaires.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The findings of the study indicate that, if the curriculum goals of Curriculum 2005 are to be implemented and achieved, (i.e. Mathematical processes such as problem-solving strategies, estimation, etc. are to be emphasised), then strategies are required to

1. provide all learners with increased opportunities to acquire a core of foundational competencies in Maths (for example, basic Mathematical skills such as mental arithmetic, and basic conceptual understandings such as how the number system works), and
2. ensure maximum use is made of available teaching time to improve Maths learning
 - a) through the creation of more effective and supportive instructional conditions; and
 - b) by ensuring that teaching time is used more efficiently and purposefully. The findings also support the notion that the social and educational context for learning and teaching is a crucial unit for analysis in curriculum reform processes, teacher development programs, and materials development.

9.2 Recommendations

In light of the above, the following recommendations are made:

9.2.1 Policy issue

Policy strategies for ensuring that the goals of the new curriculum are implemented include developing

- a) a curriculum framework which would ensure consistency in implementation of the new curriculum in terms of content (see 9.2.1.1);
- b) clearly-stated performance standards which would ensure consistency in the level of implementation, particularly in terms of levels of cognitive complexity (see 9.2.1.2);

9.2.1.1 A curriculum framework

Curriculum 2005 does not make the core content that teachers must cover explicit. The findings of the Focus on Four study on the relationship between the implemented curriculum, the intended curriculum, the attained curriculum, and the social and educational contexts for learning and teaching, suggest that teachers need a more clearly stated curriculum framework. Such a framework could serve to ensure greater congruity in teachers' implementation of the curriculum both in terms of content, and in terms of the logic with which the topics / subtopics are organised and developed over the grades. It could also serve to assist teachers to plan and pace their teaching, and make teachers' accountable for ensuring that all learners are provided with the opportunity to at least cover a core of key Maths content.

In particular, the framework could assist those teachers who lack an appropriate Mathematical background to identify which aspects of the curriculum they need to emphasise, and which aspects require less

emphasis. (Teachers would still be responsible for deciding how they went about achieving the framework goals. In other words, they would still be free to 'put their personal stamp' on their teaching.)

9.2.1.2 Performance standards

Curriculum 2005 does not make explicit the levels at which teachers in the different grades are required to cover Maths content (Maths concepts and processes). The findings of the study on the level at which the topics / subtopics were developed both within the lessons observed and by the sample of teachers over the term, suggest a need for clearly defined standards of learner performance.

In particular, the findings suggest the need for performance standards that would ensure greater consistency in the level of cognitive complexity at which Maths content is covered. Such standards could assist teachers to sequence and address increments in terms of Maths content in a much more systematic way.

This could be achieved by making explicit what learners need to know and be able to do, so that teachers are more easily able to:

- recognise or assess learner attainment of outcomes at an appropriate level; and
- assess learners continuously more uniformly (continuous assessment is difficult to moderate).

The above could be accomplished through the inclusion of examples of graded assessment items/activities/tasks for each of the topics / subtopics designed to determine if learners have attained outcomes at an appropriate level. The items/tasks/activities could include assessment criteria stated in the forte coding rubrics similar that used for the TIMSS free-response items. This would:

- a) enable teachers to measure the degree/level of learner competence against the intended curriculum and performance standards; and
- b) ensure that teachers' assessment of learner achievement can be matched to the performance standards.

9.2.2 Training and development

Strategies for ensuring that the curriculum goals are achieved include creating more effective and supportive instructional conditions; and ensuring that teaching time is used more efficiently and purposefully through materials development (see 9.2.2.1), and teacher training and development (9.2.2.2).

9.2.2.1 Materials development

The findings of the study provide evidence that materials such as textbooks are important resources for teachers and for learners. The findings also support the view that materials which provide a 'bridge' between what is intended in the new curriculum, and what teachers are currently implementing in classrooms, are required.

In particular, the study's findings indicate a need for sequenced, integrated, and graded activities that

- a) assist teachers to cover and make explicit key content as outlined in the curriculum framework,
- b) assist teachers to develop the key concepts and processes incrementally to levels which are in line with the performance standards;
- c) model appropriate teaching strategies, for example through the inclusion of suggestions on how lessons could be taught;
- d) make it possible for more able learners to do additional 'enrichment' activities so that all learners cover the same key content but do not necessarily all complete identical activities; and
- e) are designed in ways that make it necessary for learners to consider multiple approaches to solving problems.

However, such material would need to be carefully designed to match both:

1. the teaching and learning needs of the majority of teachers (i.e. the current knowledge base and experience of the teachers) and learners (the cognitive skills and abilities the learners bring to the classroom), as well as
2. the social and educational context for teaching and learning of the majority of schools.

9.2.2.2 Teacher training and development

The study's findings indicate that mechanisms for systematic teacher education programs are required if teachers are to implement and achieve the goals of the new curriculum effectively. Pre-service and in-service teacher education programs could be directed specifically at achieving the knowledge outcomes for learners as specified in the curriculum framework, and in the performance standards. Programs could also be deliberately matched to the teaching and learning contexts of the majority of schools in South Africa.

In particular, the findings suggest a need for pre- and in-service teacher education and training (in-set) on

- a) the Maths (discipline) knowledge teachers need to master if they are to put relevant content onto the Learning Area outcomes;
- b) language in Mathematics; and
- c) Mathematical pedagogical understandings and teaching strategies. For example, the findings suggest that pre- and in-set work is required on
 - developing teachers' own understanding of Maths content to adequate levels so as to ensure that they are able to engage learners with concepts and processes at more appropriate levels;
 - ensuring that the curriculum includes spoken and written Maths language. For example, by providing learners with greater opportunities to decode and interpret Maths texts and by providing learners with greater opportunities to explain and discuss their

Mathematical thinking, by defining and teaching Maths terms, vocabulary and language, etc.,

- assisting teachers to perform effective teaching strategies. For example, more effective assessment strategies; strategies for providing learners with opportunities to use and apply Maths concepts, principles and strategies to solve everyday/real life problems, whilst maintaining the Mathematical focus of the lesson so the Maths purpose is not lost, etc.; and
- assisting teachers to use and employ resource materials such as textbooks more appropriately and effectively.

9.2.3 Research

A further strategy is that of supporting on-going research on the curriculum reform process, teacher development programs, and materials development. For example, supporting research into the kinds of material that are the most appropriate and effective in terms of developing key Maths concepts and processes given the South African social and educational context.

The Focus on Four study goes some way towards establishing

- some of the social and educational contexts for Grade 4 Mathematics teaching and learning at schools that are representative of the majority of traditionally 'black' primary schools in urban areas in South Africa;
- the current knowledge base and experience of a sample of Grade 4 teachers in the Learning Area of Mathematical Literacy, Mathematics and Mathematical Sciences,
- the teaching strategies most frequently adopted by these teachers; and
- the current knowledge base and experience of a representative sample of Grade 4 learners in the Learning Area of Mathematical Literacy, Mathematics and Mathematical Sciences;
- relationships between teachers' instructional practices and learner? achievement.

However, the use of the TIMSS items did not allow for statistically significant evidence of improvement in learner achievement to emerge. As a result, no conclusive evidence of the effect of teachers' instructional practices on learner achievement could be identified. Neither was it possible to analyse data in ways that made it possible to identify other key variables that could have contributed to differences in learner achievement. Nevertheless, there may have been other qualitative effects of teachers' teaching on learners' learning that were not revealed through the use of the TIMSS items.

Clearly there is a need to develop tests that are good discriminators of

- a) Grade 4 learners' true Mathematical ability; and
- b) the effect of teachers' instructional practices on Grade 4 Mathematics learners in the South African context. (For example, test items that take into account the low reading levels of the majority of learners.)

Thus, the final recommendation of this report is that the work started by this research project be continued through the development of more appropriate test items for a follow-up investigation into the positive effects of teachers' instructional practices on learner achievement. The research would entail validating items through a battery of field tests and a series of statistical checks.

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