FACILITATING CONSTRUCTIVE CHANGE IN SECONDARY MATHEMATICS CLASSROOMS IN ZIMBABWE

by

Mary Jean Atkinson
B.Sc., University of British Columbia, 1964

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (EDUCATION)

in the Faculty of Education

© Mary Jean Atkinson 1997
SIMON FRASER UNIVERSITY
July 1997

All rights reserved. This work may not be reproduced in whole or in part, by photocopy or other means, without permission of the author.
The author has granted a non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of this thesis in microform, paper or electronic formats.

The author retains ownership of the copyright in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author’s permission.

L’auteur a accordé une licence non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de cette thèse sous la forme de microfiche/film, de reproduction sur papier ou sur format électronique.

L’auteur conserve la propriété du droit d’auteur qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

0-612-24086-X
APPROVAL

NAME
Mary-Jean Atkinson

DEGREE
Master of Science

TITLE
Facilitating Constructive Change in Secondary Mathematics Classrooms in Zimbabwe

EXAMINING COMMITTEE:
Chair: Mike Manley-Casimir

Thomas O'Shea, Associate Professor
Senior Supervisor

Celia Haig-Brown, Associate Professor
Member

Malgorzata Dubiel, Laboratory Instructor
Member

A. J. (Sandy) Dawson, Professor
Faculty of Education,
Simon Fraser University
External Examiner

Date: July 28, 1997
Abstract

This study was motivated by a desire to implement more active learning in secondary mathematics classrooms in Zimbabwe arising out of my experience there as a teacher and teacher educator. For two terms in 1993 I was a participant observer in a township school, taking one class from each of four other teachers and attempting to implement teaching methods suggested in the 1991 O-level mathematics syllabus.

In Chapter 2 I draw lessons about educational change from previous mathematics curriculum reform. I also place the teaching recommendations in the larger context of current mathematics curriculum and reform. Chapter 3 shows how many of Michael Fullan's ideas about educational change influenced the methodology of the project. Chapter 4 describes the context—the country, school, teachers, and students.

Fullan emphasises that understanding the subjective realities of others is a prerequisite for engaging in effective educational change with them. Separate chapters (5, 6, and 7) describe the two terms in the school from my perspective, the students' perspectives, and the teachers' perspectives. For me, the insider-outsider role of participant observer was difficult. The students enjoyed the teaching methods but their expectations about "silent" classrooms and difficulties surrounding language of instruction limited my effectiveness. For the teachers, expectations about "covering the syllabus" affected the extent to which they were willing to experiment with their instruction.

In Chapter 8, I search for a more effective model of professional development. To this end, I analyse other in-service projects for mathematics teachers in the region and describe in detail the workshop which grew out of my teaching experience. The workshop modeled the "cluster" concept, an idea being promoted by the Ministry whereby schools in the same locality would support and help one another.

As is typical of ethnography, the focus of the study changed as it progressed—from teaching methods only to issues surrounding assessment, curriculum, and classroom discourse. In the final chapter I state conclusions and argue the merit of doing similar classroom research in Zimbabwe because of its potential to get beyond the rhetoric to the reality of educational change.
Dedication

To the students and teachers of Zimbabwe's secondary schools.
Acknowledgments

I would like to thank:

My friends and colleagues in Zimbabwe for sharing experiences which have left me with many fond memories;

The Ministry of Education and Culture in Zimbabwe for fostering my professional growth;

The mathematics education officer of Midlands province for his interest and encouragement and making everything possible;

Students, staff, and administration at Kwelo Secondary School for accepting me as part of the school;

The mathematics teachers at Kwelo Secondary School for working with me and helping me to understand;

World University Service of Canada (WUSC), particularly the Zimbabwe field office, for facilitating my project;

My international friends at Simon Fraser for another view, community, and support;

My thesis supervisors at Simon Fraser for their faith in me;

Members of the mathematics education thesis support group at Simon Fraser for valuable feedback;

Friends at Gweru Technical College in Zimbabwe and the Open Learning Agency of B.C. for helping me, respectively, with transcribing interviews and formatting and editing the thesis.
# Table of Contents

Approval .......................................................................................................................... ii
Abstract ............................................................................................................................. iii
Dedication .......................................................................................................................... iv
Acknowledgments ............................................................................................................ v
List of Figures .................................................................................................................... viii

## Chapter One: Background and Motivation for the Study ............................................. 2
  Motivation for the Study ............................................................................................... 3
  Research Objectives and Questions ............................................................................... 7
  Outline of Chapters ....................................................................................................... 8

## Chapter Two: Review of the Literature ....................................................................... 11
  Curriculum Reform in Mathematics Education ............................................................... 11
  Research in the Teaching and Learning of Mathematics since the
    Curriculum Projects of the 1960s and 1970s ............................................................... 19
  Some Approaches to Curriculum Arising Out of Research ............................................. 32
  Evaluation of Proposed Changes to Mathematics Teaching for the
    Zimbabwean Context .................................................................................................... 34

## Chapter Three: Methodology ....................................................................................... 41
  Advantages of Ethnographic Methods for Research in Education ................................. 41
  How the Literature of Educational Change Influenced the Study ................................. 43
  Activities and Data Collection During the Field Part of the Project .............................. 51
  My Role as It Evolved ................................................................................................... 57
  Data Analysis, Interpretation, and the Writing Process .................................................. 60

## Chapter Four: Kwelo Secondary School, Zimbabwe 1993 ......................................... 63
  Description of the School .............................................................................................. 64
  The Mathematics Teachers ............................................................................................ 66
  The Mathematics Department ....................................................................................... 66
  The Mathematics Students ............................................................................................ 69

## Chapter Five: My Teaching Experience ....................................................................... 75
  Africa Report #1: 20 May 1993 .................................................................................. 75
  Africa Report #2: 24 June 1993 .................................................................................. 76
  Africa Report #3: 11 August 1993 .............................................................................. 78
  Africa Report #4: 29 August 1993 .............................................................................. 82
  Africa Report #5: 19 November 1993 ........................................................................ 83
  Africa Report #6: 28 November 1993 ........................................................................ 87
# Africa Report #7: December 1993

**Chapter Six: Students' Views and Problems**
- Assessment: Marking Routine
- Classroom Discourse and Language of Instruction
- Classroom Discourse and Group Work
- Teaching Methods: Teaching Aids and Activities
- Teaching Methods: Mathematics Club
- Curriculum: Covering the Syllabus
- Summary of Students' Views

**Chapter Seven: Teachers' Views on Assessment, Classroom Discourse, Teaching Methods, and Curriculum**
- Assessment Issues: Marking Routine
- Classroom Discourse and Language of Instruction
- Teaching Methods
- Curriculum: Core Syllabus and Alternative Syllabus

**Chapter Eight: Inservice for Mathematics Teachers in the Region and the Cluster Workshop**
- In-Service for Mathematics Teachers in the Region
- The Cluster Workshop
- Evaluation of the Workshop

**Chapter Nine: Summary and Conclusions**
- Response to Original Objectives and Research Questions
- The "What" of Educational Change
- The "How" of Educational Change
- Importance of the Ethnographic Approach to Educational Research for this Study

**List of References**

**Appendix A: O-Level Mathematics Syllabus**

**Appendix B: A Brief Political and Educational History of Zimbabwe**

**Appendix C: Glossary of Terms**

**Appendix D: Permission to do Research**

**Appendix E: List of Resources**

**Appendix F: Student Feedback**

**Appendix G: Interview Guides for Teacher Interviews**

**Appendix H: The Isometry Game**

**Appendix I: Sample Lessons**
List of Figures

Figure 1: Map of Zimbabwe .................................................................4
Figure 2: Data Collection Timeline ....................................................55
Figure H1: The Game Board for Isometry ......................................222
Figure H2: The Playing Cards for Isometry .................................223
Figure I1: Area of a Leaf .................................................................226
Figure I2: The Zimbabwe Bird .........................................................227
Figure I3: Height of a Flagpole .......................................................228
Figure I4: Matrices from Football Results ...................................229
St. Augustine's
"the imposing church is a landmark of the school" (p.5)

typical rural school
"our student teachers ... were placed in all types of schools—rural schools, township schools, and former group A schools" (p.6)
Chapter One
Background and Motivation for the Study

In an international review of mathematics education, Howson and Wilson (1986) comment that, despite what is urged by educators and in official reports and what can be seen in the classrooms of some outstanding teachers, a typical secondary mathematics lesson relies heavily on the textbook and the traditional teaching pattern of exposition-examples-exercise. Class rather than group teaching is the norm and apparatus is rarely used. A report (Macfarlane, Makhurane, Matos, & Merkus, 1990) on mathematics and science teaching in countries of the SADCC region (Southern Africa Development Coordination Conference) recommends more active participation of pupils in the learning process. After surveying mathematics teachers in Zimbabwe, Jaji (1990) concludes that although the intended curriculum emphasises discovery learning, problem-solving and conceptual understandings, the predominant approach to teaching is chalkboard explanations.

This study, based on current theory of educational change, applies methods of ethnographic research to find out more about teaching and learning mathematics in Zimbabwe. To improve education, it is important to first advocate worthwhile changes and then to implement them effectively (Fullan, 1991). In Zimbabwe, the mathematics syllabus advocates certain teaching methodology, yet what is suggested is not common practice. If these suggestions are worthwhile, then how can teachers be helped to change their practice? In a country like Zimbabwe, with limited resources, it is particularly important to manage change effectively. Presently, many children are choosing not to write the O-level examination and many who do write are not passing. It is hoped that insights, about curriculum and about effective change processes, gained from this study will be useful to mathematics teachers and mathematics curriculum developers in Zimbabwe.

There has been considerable curriculum development in Zimbabwe since independence in 1980. The current syllabus in mathematics has been developed locally in co-operation with the University of Cambridge Local Examinations Syndicate; it was examined first in 1991 (Appendix A). The syllabus contains a section on teaching methodology. It suggests that teaching should develop concepts from the concrete and familiar moving to the abstract. It further suggests that principles should be based on sound
understanding of concepts and learned through guided discovery or activity-based discovery. Skills should be learned only after mastery of principles and concepts; skills taught in other subjects should be reinforced. It recommends that group work be organised regularly and that mathematics should build an interest and confidence in tackling problems, in familiar and unfamiliar contexts.

The teaching methodology of the Zimbabwe mathematics syllabus then, is an educational policy which does not seem to be reflected in practice. Mathematics is rarely taught this way, in Zimbabwe or elsewhere. Why not?

To address this question, I became a participant observer in a school in a high density area of a small town in Zimbabwe. During the last two terms of 1993, I taught four mathematics classes, one taken from each of four other teachers, and attempted to implement the methodology suggested in the syllabus, using additional resources provided to the school as part of the project. I held formal and informal discussions with the teachers and obtained feedback from pupils. The teaching experience culminated in a workshop held at the school. The participants were mathematics teachers from the school and nearby schools, personnel from the regional office of the Ministry of Education, and lecturers from local teachers’ colleges. The workshop was intended to model the “cluster” concept which the Ministry was promoting as a possible solution to some of the difficulties in schools. The concept was that schools in the same locality with similar problems might work together to share resources and solve problems.

The thesis is written primarily with a Zimbabwean audience in mind. Other readers, not familiar with this context, are referred to Figure 1 for a map of Zimbabwe and to the appendices for a brief political and educational history of Zimbabwe (Appendix B) and a glossary of terms (Appendix C). The glossary contains words and acronyms which may not be familiar to North American or other non-Zimbabwean readers. The latter must also judge for themselves the relevance of the study to contexts other than Zimbabwe.

Motivation for the Study

I first went to Zimbabwe in 1984 with Project Overseas of the Canadian Teachers’ Federation (CTF). The purpose of Project Overseas is to give professional assistance to fellow-teachers. Three of us worked with the Zimbabwe Teachers’ Association (ZIMTA) to provide two two-week in-
service workshops for teachers of junior secondary English, science, and mathematics in Harare. These teachers were all from rural schools and many had moved from primary to secondary teaching at independence in 1980. Consequently, though we did discuss teaching, the primary focus of the workshops, at least in mathematics, was content upgrading.

The CTF/ZIMTA workshops were a very interesting and enjoyable experience for me, as they were, I think, for other participants. However, I was left with many questions about this sort of activity. What exactly would teachers take back to their classrooms? How would it change their teaching, if at all? What was our role as Canadians? Our Zimbabwean colleagues told us: “Do it your way; we’ll see what we think is worthwhile in what you do that is different.” They were more than competent to teach the courses. We were not
very familiar with the curriculum or with conditions in the schools. We did not visit schools during the course, as they were not in session. It seemed to me that, primarily, we provided money and some organisational skills. Although it was an interesting cross-cultural and educational experience for all of us, I was left wondering what impact the project would have on the schools.

That year, in 1984, pupils who had started Form One at independence were completing their O-levels and expecting places at A-level. There was a shortage of A-level teachers, particularly in mathematics and science. I wanted to be a part of the educational transformation happening around me; I knew such an opportunity would not present itself again. When the other Canadians on Project Overseas went home I extended my leave and stayed on with the World University Service of Canada (WUSC) program which had been recruiting Canadian secondary school teachers for the Ministry since independence.

I taught science and mathematics for three years at St. Augustine’s Mission, Penhalonga. St. Augustine’s, in the hills on the Mozambican border, has an interesting educational and political history. Established by the Anglican church, it was the first secondary school in Rhodesia for African children. Its political history is reflected in the statue of the guerrilla fighter, which along with the imposing church, is a landmark of the school. The statue reminded us that the war was fought, in part, so that everyone could have an opportunity for secondary education—the guerrilla holds a gun in one hand and a book in the other. The school had stayed open in the midst of the war when many other schools had closed; many of the students crossed the border to Mozambique to join the struggle.

Like the CTF/ZIMTA course, teaching at St. Augustine’s was a very positive experience for me. However, I was aware that St. Augustine’s was an academically-elite school and not typical of schools in Zimbabwe. Certainly, it was not like the schools where our in-service participants were teaching. The students were selected on the basis of their grade seven results and nearly all passed O-level well. Most of our A-level students continued on to university. Nearly all the teachers had university degrees and graduate certificates in education. The school was not very different from what it had been before independence but I knew that significant educational changes had taken place in the country since 1980.
In 1988, I transferred to Gweru Teachers’ College (GTC) on a second WUSC contract. Now, finally, I came to know the reality of schools and education in post-independence Zimbabwe. Our student teachers spent an entire year in the schools for their teaching practice and were placed in all types of schools—rural schools, township schools, and former group A schools in the urban areas. We were required to visit each student three times for assessment purposes over the course of the year. Even this was difficult, given the distances involved and the shortage of reliable transportation. During my three years at GTC, I sat at the back of many classrooms, observing lessons which were adequate, but not particularly inspiring. I wanted to see the children doing more. To me, they seemed passive, but willing, even eager, to learn. Was this related to the teaching? Would the lessons be different if teachers had more knowledge and more resources? In the difficult circumstances, what would I do if I were the teacher?

The constraints and pressures on teachers are considerable. These include poorly furnished classrooms, large class sizes, overloaded timetables, and a shortage of resources; sometimes of such basic things as paper and textbooks. Many schools are in remote locations with difficult living conditions for teachers. Students must continue on to the next form even if they are having difficulty. Yet parents expect teachers to see that their children pass at O-level.

My experience at the teachers’ college made me want to learn more about the teaching of mathematics and I applied to do the master’s program in mathematics education at Simon Fraser University (SFU), on completion of my contract. At about the same time, I read a consultancy report, published by the Free University of Amsterdam, based on conversations with many mathematics and science educators in the region. Among other things, the report called for curriculum and teaching materials which were more relevant and designed for use in the prevailing circumstances, as well as more educational research and utilisation of existing research results in the classroom. It attributed the failure of local efforts to address problems in the learning of mathematics and science partly to ineffective teaching styles which emphasised rote learning over thinking and problem solving, and partly to inadequate initial training of teachers and lack of professional support for practicing teachers. The report advocated that teaching stimulate active participation of pupils in the learning process and recognise their
learning difficulties. It also recommended that the region discover more about its own educational problems and potential solutions rather than rely on results of research carried out elsewhere (Macfarlane, et al., 1990). Some of these recommendations were similar to the methodology statements in the current Zimbabwean syllabus, which I knew were not being implemented in the classroom.

Perhaps I could help and, at the same time, find answers to some of my own questions. The report stimulated me to explore the possibility of doing my thesis work in Zimbabwe. This was acceptable to Simon Fraser so I obtained endorsement from the Ministry of Education and Culture and the Zimbabwe Research Council (Appendix D) and financial support from WUSC. On completion of the course work for my degree, I returned to Zimbabwe in May of 1993.

**Research Objectives and Questions**

The original objectives of the project were to:

1. Produce modular materials (so that they could be readily adapted to other syllabuses) for teaching mathematics which were closely tied to the current syllabus in Zimbabwe in both content and methodology, and would help teachers plan lessons which utilised a variety of teaching methods.

2. Involve teachers in reflective practice through the use of additional teaching resources and the preparation of teaching materials.

3. Assess and evaluate the influence of this experience on changing teacher and pupil behavior.

In particular, the study sought answers to the following questions:

1. Does the use of these resources facilitate an observable change of teaching styles to ones which are more pupil-centred and utilise a greater variety of methods?

2. What is the reaction of the teachers to the teaching materials and their use in the classroom and to a model of in-service training based on reflective practice?

3. What is the response of pupils to the use of the materials? Is there any change in their achievement? Are they more actively involved in the lessons? Do they enjoy mathematics more?
The materials which I produced at Simon Fraser consisted of five binders of ideas for teaching activity-based, discovery lessons, organised according to broad syllabus areas. In addition, I assembled a collection of teaching aids. For example, cards, dice, Dienes blocks, Cuisenaire rods, calculators, and geoboards (Appendix E).

As is typical for an ethnography, the focus changed as the study progressed. While the original objectives and questions remained, the following objectives became as important as well:

1. Understanding the context of education, particularly mathematics education, in a township school a decade after independence.
2. Determining factors which influence how teachers prepare and teach their lessons.
3. Providing a forum for teachers to articulate their concerns about teaching mathematics.
4. Modeling how the “cluster” concept, an idea promoted by the Ministry whereby schools in the same locality would support and help one another, can be used to provide meaningful in-service to teachers.

At the beginning of the study it was assumed that the curriculum methodology represented a worthwhile change advocated by Zimbabwean mathematics educators. This was a given, and the original objectives focused on how teachers could be helped to implement these. As a result of my experience in the school, it became important to seek answers to additional questions:

1. What exactly was the origin of the curriculum methodology statements?
2. Which of the statements represent worthwhile educational changes in the current context?
3. What is appropriate mathematics curriculum for the majority of students?
4. How can in-service for mathematics teachers help to address their concerns about students, curriculum, and assessment?

Outline of Chapters

Chapter 2 reviews the history of curriculum development in mathematics, research on the learning of mathematics, and current ideas about mathematics curriculum. The impact of the new mathematics
programs of the 1960s and 1970s in East and Southern Africa is examined with a view to informing curriculum change in the 1990s. Contemporary approaches to mathematics curriculum are presented and analysed. Although much of the literature in mathematics education reviewed is published in North America, there is an attempt to put an international perspective on mathematics curriculum.

Chapter 3 describes how the study was conducted, making reference to the literature on qualitative research, and on educational change and teacher development, which both informed the design of the study. Again, much of the published literature on educational change and teacher development is based on research conducted in the United States and Canada. Little educational research, particularly of a qualitative nature, has been done in Third World countries, and that which has been done has often been done by expatriate researchers. Nevertheless, as education is a universal enterprise, an attempt is made to distil what is generic and likely to apply to this study.

My role was that of participant observer. Briefly, data collected included interviews with teachers at the beginning and end of the project; field notes on daily events and conversations, as well as analytical reflection on these; documents such as schemes of work, minutes of meetings, teachers' magazines, and local newspaper articles; notes on class discussions with pupils; and written feedback from pupils and from teachers at the workshop. Chapter 3 discusses methods of data collection and analysis in more detail and also comments on my role as it evolved in practice.

Chapter 4 discusses the context of the study. It includes a summary of the social, political, and educational environment in Zimbabwe when I returned in 1993. There is also a brief history and description of the school. The resources of the mathematics department, the background of the teachers, and the nature of the mathematics pupils are described, based on initial interviews with the teachers, school documents, and student comments.

Chapter 5 discusses the teaching experience from my point of view. It relies heavily on Africa Reports, a series of six reports which I sent back to my supervisors at Simon Fraser during the course of the research. These were compiled from my field notes. Chapter 5 extracts from Africa Reports excerpts pertaining to the data categories: teaching resources and activities, groupwork, mathematics club, marking, language, and communication. It also
develops the themes used to organise the following two chapters: assessment, teaching methods, classroom discourse, and curriculum.

Chapter 6 summarises feedback from pupils about teaching methods and about issues related to assessment, classroom discourse, and curriculum which surfaced during the course of the study. It presents the teaching experience from the perspective of the students.

Chapter 7 summarises interviews and discussions with teachers, picking up on ideas and themes presented in Chapters 5 and 6. In the final interviews I asked teachers to respond to my own growing understanding, and to concerns expressed by the students.

Chapter 8 examines in-service for mathematics teachers in the region based on my personal experience with a number of projects. It also describes and evaluates the workshop we held at the school towards the end of my stay. The workshop was designed to model the "cluster" concept currently being promoted by the Ministry whereby schools in the same locality would support and help one another. This chapter relies heavily on a report about our workshop prepared for the Ministry by the education officer and me, as well as documents from other in-service projects.

Chapter 9 reflects on the original research objectives and questions. It analyses the experience in terms of educational change theory in an attempt to provide insights to teachers and others concerned with mathematics curriculum in Zimbabwe. It also argues the merit of pursuing similar ethnographic research in Zimbabwean classrooms.
Chapter Two
Review of the Literature

Fullan (1991), writing on the meaning of educational change, cautions us to be wary of innovation and reform. Innovations are not ends in themselves; change is not necessarily progress. He raises two problems: the appropriateness of suggested changes, and a "bias of neglect" regarding needed changes that are not proposed. The 1970s were characterised by concern about implementation failure. Fullan points out that inappropriate changes which are rejected in practice are actually successes except for the time, energy, and frustration involved in the effort to implement them. In particular, jurisdictions with limited resources cannot afford to squander them on ill-conceived change. Ideally, an appropriate change is effectively implemented. In a survey of the literature on the implementation of educational policies in sub-Saharan Africa, Maravanyika (1990) stresses that concern with problems of implementation should not take attention away from the fundamental issue of designing policies that can and should be implemented.

What, then, can be considered to be a worthwhile, appropriate change? Fullan suggests three criteria: it should be needed, it should be technically sound, and it should be feasible in particular circumstances. The following review of the literature examines the recent history of mathematics curriculum and reform as well as research on the learning and teaching of mathematics. The review draws lessons about educational change from previous experience with mathematics curriculum reform, particularly the implementation of "new" and "modern" mathematics programs in Africa. It also places the methodology statements of the current Zimbabwean mathematics syllabus in the larger context of international mathematics curriculum and reform. The intent is to analyse the extent to which these statements can be considered a worthwhile, appropriate change that should be implemented in the particular circumstances of Zimbabwe.

Curriculum Reform in Mathematics Education

The 1960s witnessed unprecedented change in mathematics curriculum internationally. This was primarily in response to a perceived need for better professional scientists and mathematicians in America and Europe, and it became a world-wide phenomenon. The changes were primarily modernisation of content and emphasis on inquiry-oriented
teaching (Howson, Keitel, & Kilpatrick 1981; Moon, 1986). Now, in the 1990s, there is again an international call for reform. The intervening years have been characterised by reaction to reform and by increased research on the learning and teaching of mathematics. Current proposals for change advocate a teaching approach based on constructivist theories of learning and extensive use of calculators and computers to develop mathematical concepts. Technology has influenced not only the extent to which mathematics is used in most vocations and professions, but also the way in which it is used. It has affected how professional mathematicians do mathematics as well. Recognising that more students will need to quantify, analyse, and problem-solve in their future careers, proposals for change also recommend a core curriculum exposing all students to a variety of mathematical topics. Mathematics educators recognise that these changes will be difficult to realise without corresponding changes in assessment practices.

Howson, et al. (1981) classify the approaches to teaching mathematics which grew out of the reform movements in the 1960s and 1970s into five categories: (a) behaviorist, (b) new mathematics, (c) structuralist, (d) formative, and (e) integrated teaching. The behaviourist approach is exemplified by programmed learning instruction, computer-assisted learning, and the use of behavioural objectives. The new mathematics was an axiomatic approach emphasising proof, logical argument, and precision of language, while de-emphasising computational skill and applications of mathematics. The structuralist approach was meant to foster creative and independent thinking by getting learners to behave like professional mathematicians; discovery learning was an important component of this approach. The formative approach is based on the ideas of Piaget and later cognitivists. Advocates of this approach believe that learning is facilitated by reflection on self-directed manipulation of real objects and that the organisation of learning should take into account the child’s cognitive development. In an integrated teaching approach, problem areas from “real-life” determine the curriculum. The context of mathematical ideas takes precedence over ideas in abstraction and so applications are central to this approach.

After carefully examining the history of a number and variety of curriculum projects, Howson et al. (1981) conclude that the practical results of nearly twenty years of concentrated, frantic curriculum development in
mathematics were insignificant. Behaviourist projects seemed to inhibit the development of intuitive ideas and encourage the development of misconceptions. Projects based on the new mathematics proved difficult to implement, particularly in primary schools. It seems they ignored fundamental aspects of how children learn. Structuralist projects were difficult to evaluate. Projects based on the formative approach seemed to ask too much of teachers. They were often expected to develop their own curriculum materials; many would have preferred more pupil materials. The integrated teaching projects were very demanding for teachers without broad backgrounds and interests. In fact, by the end of the seventies the strident reformist advocacy of mathematicians in the sixties had given way to questioning and criticism, and international forums called for research rather than reform (Moon, 1986).

Implementation of the New and Modern Mathematics Programs

Experience with these large scale curriculum projects has shown that contrasting cultural contexts impose major constraints on the transfer of educational innovations, particularly those which advocate changes in teaching methods (Crossley, 1984; Howson et al., 1981; Lillis, 1985; Wilson, 1992). Curriculum in Africa was influenced most by School Mathematics Study Group (SMSG) of America, a “new” mathematics project, and School Mathematics Project (SMP) of Britain, a “modern” mathematics project. These were similar in that they both updated content; they differed in that SMP had an emphasis on applications, inquiry, and activity. Wilson (1992) suggests that the underlying philosophy of the “modern” mathematics curriculum—activity, investigation, and discovery—never took root in Africa because of the realities of African primary schools. Lillis (1985) suggests that these curricula were imbued with expatriate assumptions which were not realistic or appropriate for the context. To address Fullan’s questions for these curricula: [were] they needed? [were] they technically sound? [were] they feasible in the circumstances?, the history of SMSG and SMP will be examined in more detail, first in America and Britain, then in Africa.

Comparison of SMSG and SMP.

The major impetus for the formation of the School Mathematics Study Group (SMSG) was concern from research mathematicians that the school
curriculum did not prepare students for university mathematics. A conference of mathematicians from across the United States in 1958 was followed by writing workshops in July and August of 1958, 1959, and 1960. The intent was to produce a model curriculum in the form of a textbook series which would stimulate commercial publishing firms and individual textbook writers to produce similar materials. The decision to produce textbooks was very deliberate; it was felt that if SMSG was to influence the mathematics curriculum in the United States, this influence would have to be exerted through the medium of sample textbooks. The texts had considerable explanatory material, little illustration, and did not consider applications; it was intended that their appeal be based solely on the mathematical content (Wooton, 1965). Like SMSG, the original intention of the School Mathematics Project (SMP) in Britain was to modernise the curriculum and to encourage more students to study mathematics at university. However, SMP also aimed to make school mathematics more exciting and enjoyable, and to impart knowledge of the use of mathematics in the modern world. Advocates of SMP courses argued that their value lay in a different teaching approach, that the experimental discovery approach led to greater understanding of mathematical concepts (Thwaites, 1972).

University, college, and high school teachers of mathematics wrote the SMSG materials. Volunteer teachers from experimental schools attended a conference at the beginning of the school year in order to become familiar with the content and philosophy of the course, tried the materials in their classrooms, and provided the authors with written feedback. In contrast, the SMP model of curriculum development was school-based and depended on the identification and recruitment of teachers with a sound grasp of mathematics, classroom experience, and pedagogical insight. The first SMP course led to a special SMP O-level examination and was written by experienced mathematics teachers from eight prestigious independent schools who cooperated closely with the examiners. Examinations and classroom practices did not correspond as closely for later versions of SMP (Thwaites, 1972).

Both programs also produced curriculum materials for non-college-bound students. The SMSG textbooks, modified versions of the original grade 7-9 materials, used simpler vocabulary. The expository sections came in smaller chunks and the same material was covered in twice the time
(Wooton, 1965). In Britain, a different group of teachers produced a series for secondary modern schools and comprehensive schools which was a simplified version of the first set of SMP books with less demanding vocabulary and less content. As mixed ability teaching became more common in Britain, the initial books were followed by a variety of curriculum materials: additional textbooks to provide an alternate route to O-level, a workcard scheme for mixed ability classes, booklets for the lower ability group, and finally, a new textbook series pitched at three different ability levels. Because assessment was carried out in the schools for the bottom 40% of students, the materials for this group included tests (Thwaites, 1972).

SMSG produced an elementary curriculum (grades 4-6) during the summer of 1960. The writers were college and elementary teachers, and an experienced elementary school teacher tried the units on two classes of children present at the writing workshop (Wooton, 1965). In the early 1970s the SMP 7-13 project produced workcard materials for elementary children. However, the number of teachers involved and the lack of expertise of most elementary school teachers limited the school-based model of curriculum development, and SMP did not venture further into materials for younger children. Another major British project, the Nuffield primary project, produced materials for teachers rather than pupils on the premise that discovery learning could not come through textbooks. The teachers' guides were confusing to some teachers, though, and many would have preferred to have had pupil materials (Moon, 1986).

Both SMSG and SMP were criticised for not providing children with arithmetic skills. However, the SMP materials and curriculum were more successful in that SMP did not experience the negative impacts of SMSG (Howson et al., 1981). The SMSG emphasis on deductive reasoning, rigour, symbolism, and abstraction made it difficult for many students to learn the mathematics, especially elementary students. Howson and Wilson (1986) maintains that SMP and other formative projects were more successful than SMSG and other new mathematics projects because the curriculum process meant that they were based on models of student learning and actual classroom situations. Because teachers were more involved in the preparation and trial of the British materials, they were more grounded in practice. The American projects were dominated by university professors and
used a research-development-dissemination strategy borrowed from industry; teachers were primarily consumers of the materials.

**SMSG and SMP in Africa.**

The African Mathematics Programme (AMP) or “Entebbe Mathematics” had its roots in the SMSG project and was funded primarily by the United States Aid to International Development (USAID). The Entebbe project produced materials for primary schools, for secondary schools (both O-level and A-level), for teacher-training institutions, and for in-service work with teachers. The materials were written during July and August from 1962 to 1969; first in Entebbe, Uganda, then Mombasa, Kenya. Draft materials were tried out in the schools in various countries in East, West, and Southern Africa and underwent several revisions. Editing and printing were done in the United States. Initially, the Entebbe project was dominated by the American mathematicians and the writing was strongly influenced by advocates of SMSG, but African input was significant in the revision of the materials (Wilson, 1992). Holiday courses, which concentrated on the upgrading of content knowledge and feedback about the draft materials, were organised for teachers and teacher-trainers. In 1970, a five year program focusing on in-service work with primary teacher-trainers was introduced to facilitate implementation of the Entebbe materials at the primary level.

Some British expatriate teachers who were using SMP textbooks in the more elite secondary schools in Uganda and Kenya at the time of the Entebbe project undertook to adapt these materials under copyright from SMP in the United Kingdom (Wilson, 1992). This first phase produced the School Mathematics Project for East Africa (SMPEA), a four year secondary course. A second phase took place at the Kenya Institute of Education (KIE) from 1968 to 1970, where these materials were revised to become School Mathematics for East Africa (SMEA). There was a greater change in syllabus, language, and style going from SMPEA to SMEA than SMP to SMPEA, but the writers were still expatriate mathematics teachers and teacher-educators. Both these phases were supported by an in-service program in Kenya, facilitated by SMP curriculum developers and teachers using SMP in Britain. These people came to Kenya from Britain for holiday workshops.

Whereas the Entebbe project produced materials for primary, secondary, and tertiary levels, the British projects were entirely directed at
secondary O-level. The basic mathematical content of the two secondary books was similar, but the approach of SMEA was inductive and intuitive; whereas Entebbe was deductive and more rigorous. The Entebbe textbooks were detailed and came with a complete teachers' guide; the SMEA books assumed teachers were more mathematically competent. Average and weak students found Entebbe difficult and teachers were not able to help their pupils much. Schools which adopted the SMEA program had fewer problems. Primary programs (Entebbe and locally developed “modern” primary ones) were more difficult to implement than the secondary courses (Mwari, 1980; Pythian, 1971).

Comparison of the Kenyan and Tanzanian experiences with the new and modern mathematics.

It is instructive to examine the Kenyan and Tanzanian experiences with Entebbe mathematics and SMEA in more detail. In 1962, a Mathematics Centre was established in Nairobi with American support. Its mandate was to introduce new mathematics curriculum into Kenyan schools. However, by 1965, the East African countries had decided that the SMP texts met their needs better than the Entebbe texts, and the focus of the centre switched to rewriting the SMP texts (Lillis, 1985). In 1970, Kenya introduced Kenya Primary Mathematics (KMP), a “modern” program developed at KIE for all primary schools. Consequently, by 1980, all secondary schools had adopted SMEA and, by 1981, the only examination syllabus was the modern one based on SMEA. (Since 1969 there had been separate examination syllabuses primarily defined by the different texts in use.)

The first schools to adopt SMP, and subsequently SMEA, did so voluntarily. These were high status schools with British expatriate mathematics teachers. Some government schools also voluntarily adopted SMEA. It was only in 1978, when it became mandatory, that the poorer government schools and “harambee” or “self-help” schools introduced the program. Difficulties then arose with the implementation of the syllabus. During this mass dissemination phase, roughly from 1971 to 1978, there was an attempt to provide support for teachers. It was first directed at secondary teachers, then, after 1977, at primary teachers. However, it did not reach the teachers most in need, in the majority of schools. What worked for the elite “equivalency” schools did not work for these grass-roots schools with far
fewer resources, unselected pupils, and less-qualified teachers. In 1981, modern mathematics in Kenya was abolished by presidential decree (Lillis, 1986).

In contrast, from 1966, Tanzania experimented with both the Entebbe and the SMPEA/SMEA programs and started writing its own materials in 1973. Tanzanians attended the international meetings in Nairobi and also mounted their own series of seminars and workshops starting from 1966. By 1976 there was a single program in all schools which was an amalgam of traditional mathematics and both the American and British approaches to "modern" mathematics. The Tanzanian program was less rigorous than the Entebbe mathematics and emphasised both understanding and practical use. For example, it included units on simple book-keeping and ratio and proportion. Like SMP, it advocated a discovery approach and project work and was organised spirally (Howson, 1987; Mwari, 1980). Though influenced by the other curriculum projects, the authors developed their own course. Howson (1987) concludes that it was probably the most educationally successful.

The Tanzanian primary materials were written in KiSwahili. KiSwahili already had an extensive mathematical register; nevertheless, other vocabulary had to be invented to convey some of the concepts of the new mathematics. The fact that instruction at the primary level was in KiSwahili facilitated the teaching as both pupils and teachers were fluent in the language of instruction. The Tanzanian program encountered difficulties at the secondary level where the language of instruction in science and mathematics was English. As a consequence of the language policy at the primary level, many secondary students were weak in English. Whereas in Kenya, the programs encountered the most difficulties in the "harambee" secondary schools and primary schools. In Tanzania the problems were in the secondary schools.

Reasons for the difficulties encountered by the new and modern mathematics programs in Africa.

In summary, there are a number of reasons why the implementation of these programs was even more problematic in Africa than elsewhere. First, the model programs, SMSG and SMP, assumed that all students would continue to secondary school. In Africa, primary education is terminal for the
majority of pupils. This made much of the content questionable. Many children at primary level missed the opportunity to learn mathematics which would have been more useful to them. Second, it was impossible to provide adequate material support. There were not enough textbooks, and the distribution of those that were available was often delayed. Teaching aids and supplementary reference books were in short supply. Third, many teachers were underqualified and inexperienced, particularly teachers at the rural secondary and primary schools. They had difficulty interpreting the materials, despite the effort put into seminars, workshops, and zonal meetings. In any case, the in-service did not reach all teachers. Fourth, difficulties were compounded by issues related to language. Children were often struggling to master the language of instruction as well as the language of mathematics. Considering criticism the model curricula received with regard to abstraction of language when English was the first language of the pupils, these difficulties were formidable. Also, the fact that students tended to view examination results as the only valid criteria of learning nullified many of the aims of SMEA (Howson, et al. 1981; Lillis, 1985; Mwari, 1980).

Lastly, the teaching methodology was also problematic. Both preservice and in-service programs concentrated on teaching content, neglecting the implied methodologies. Overcrowded classrooms and heterogeneous classes resulting from expansion of education systems presented limitations to the use of discovery and activity-based methods. In addition, the British models, especially, emphasised communication amongst pupils and encouraged them to ask questions. Lillis (1985) argues that this inquiry approach was incompatible with the authoritarian teacher-pupil relationships which obtained in the African context.

Research in the Teaching and Learning of Mathematics since the Curriculum Projects of the 1960s and 1970s

The next part of the literature review examines research on learning by cognitive scientists and by mathematics educators in order to reveal the roots of the current reform agenda in mathematics education. It considers the implications for teaching of research on cooperative learning in mathematics, mathematics as it is used by different cultural groups (ethnomathematics), and using calculators and computers in mathematics classes. It also describes some approaches to curriculum arising out of research.
Research on Learning From Cognitive Science

Cognitive researchers in areas other than mathematics education (information processing psychology and artificial intelligence; developmental and social psychology) often use mathematical tasks as the domain for their investigations. Thus, the results of their research are of interest to mathematics educators and are having significant impact on current recommendations for mathematics curriculum and instruction.

Problem-solving research.

Research by cognitive psychologists has focused on processes as opposed to outcomes of learning. Individuals have been observed carefully as they attempt problem-solving tasks. These range from puzzle problems which require no domain-specific knowledge, for example, the Tower of Hanoi problem and variations of the African river crossing riddle to more complex tasks such as games of strategy (Chess, Go, and Bridge), medical diagnosis, and mathematics and physics problems. In the Tower of Hanoi problem, the solver must move a pyramid of disks from one to another of three pegs, under the conditions that only the top disk on any peg may be moved and a larger disk may never be placed on a smaller. In the African river crossing problem, a human must transport across some water a predator (A), its prey (B), and some food (C) two at a time. Neither A nor C can be left alone with B on either shore. For the non-puzzle types of problem there is definitely an expert/novice distinction with regard to previous knowledge which does not exist for the puzzles and riddles.

By the early 1970s computer programs had been developed which exhibited many of the main features of human behaviour in solving well-structured puzzle-like problems. It seems people conceptualise problems in terms of a problem space that can be searched selectively for a solution (Simon, 1979). Experiments with problem isomorphs (problems which can be solved in a similar way but are not obviously related) indicate that people have great difficulty transferring learning from one task to a different but closely related task. The way in which the problem is presented, or represented by, the solver affects how easily the connection can be made. These experiments indicate that transfer of learning is very difficult even when no specific knowledge is required for the task. It is even more difficult
when an individual does not have extensive knowledge in a particular domain.

Glaser and Chi (1988) summarise the extensive research on problem-solving behaviour of experts and novices. It seems that experts excel only in their own domains where they perceive large meaningful patterns. In comparison to novices, they have superior short term and long term memory, see and represent problems at a less superficial, more principle-centred level, spend a great deal of time analysing problems qualitatively before pursuing a particular solution method, and have strong self-monitoring skills. Experts are no better than novices at recalling information that has no meaning for them; it seems their expertise depends on having domain-specific patterns organised in memory. Expertise depends on extensive experience within a particular task domain and consequently develops over a period of time. Thus, the success of experts is context specific—it seems to depend not only on the way they approach problems but on a large knowledge base as well.

Research in developmental psychology.

Much work in cognitive science has grown out of Piaget's studies of how knowledge develops in children. Piaget found that children actively explore their environment, assimilating and accommodating what they learn to what they already know. Pre-school children do not understand that actions can be undone (reversibility) and that basic properties of objects (number, mass, length, area, and volume) remain the same even though outward appearances may change (conservation). In comparison, young school-age children recognise reversibility and conservation. The latter reason inductively and manipulate objects physically in order to solve problems (concrete operations). They understand cause and effect relationships only if they observe them. Older children and adults are able to reason deductively and to generate and test hypotheses in the absence of the objects of their thinking (formal operations) (Sutherland, 1992; Vuyk, 1981).

In Piaget's experiments a child is given some material to manipulate and then is observed and questioned about what he or she does and why. Instructions are as simple as possible and adjusted to the child's language; in the interview, questions are adjusted according to the answers of the child. Emphasis is on the child's behaviour and way of tackling the problem.
Piaget and his colleagues developed tasks to determine the kind of thinking a child uses. For example, in a typical conservation task a child aligns two rows of identical counters, establishing one-to-one correspondence; the investigator then spreads one row apart; a pre-operational child will claim the longer row has more.

Piaget’s own experiments with young children were naturalistic, observational studies of cognitive behaviour. He was not particularly concerned about the effects of actively modifying the child’s environment (instruction) or with the social interactions of the child. Other investigators have studied the performance on Piagetian tasks of both children and adults from many different cultural groups in order to assess the effect of other variables on learning (Dasen, 1972; Lancy, 1983; Stigler & Baranes, 1988). The age norms for passing concrete operational tasks vary widely across cultures; this is probably due to the inappropriateness of tasks designed for middle-class European children in other settings rather than intrinsic differences in cognitive development. It seems not all adults attain concrete operational thought, let alone the next Piagetian stage of hypothetico-deductive reasoning. Attempts to show a relationship between schooling or out-of-school mathematical practices and success on Piagetian tasks have produced varied results. Overall, the results of this research are mixed and inconclusive (Dasen, 1972; Saxe, 1991) although they do lend support to the universality of Piaget’s theory and to formal schooling as a significant variable affecting performance on Piagetian tasks.

Situated cognition studies.

Researchers (Lave, 1984, Lave & Rozoff, 1988; Saxe, 1991) who conduct “situated cognition” studies maintain that research which attempts to identify cultural influences on Piagetian tasks through correlational analyses misses important interplay between culture and cognition. These researchers are interested in how mathematical understandings develop in out-of-school contexts and their work is influenced by Vygotsky’s view that social interaction mediated through language is an important factor in cognitive development. Researchers develop mathematical tasks from participant observation and interviewing groups “in practice,” that is, groups of people engaged in common endeavours within their own culture. For example, researchers have studied: tailors and rice farmers in Liberia; dairy workers,
grocery shoppers, and weight watchers in the United States; construction foremen, fishermen, lottery game bookies, and street vendors in Brazil; and navigators in Micronesia (Lave, 1988; Nunes, 1992; Saxe, 1991; Stigler & Baranes, 1988). Work on cognition in practice indicates that people are very good at developing the mathematics they need to carry out tasks which are important to them. They do not usually use school-based algorithms or standard measurement techniques. They choose their problems and only formulate a problem when they know they can arrive at a solution. Their solutions are very situation-specific.

Saxe (1991) specifically focused on candy sellers of different age groups in order to examine everyday cognition from a developmental perspective. He found that young candy sellers on the streets of Brazil were able to function effectively because they were socially supported by older sellers and adult relatives, customers, and store clerks. The younger sellers either got help or avoided problems; older sellers were more independent and accomplished more complex mathematical tasks. Saxe’s research supports the view that children are able to accomplish more when they interact with and get assistance from adults and that this plays a more significant role in cognitive development than earlier thought.

A major goal of “situated cognition” research is to explain the understanding that seems to come with learning in everyday contexts and the lack of understanding that so often accompanies learning in formal school settings. Many unschooled adults and children are mathematically-effective in their environment. Giving the same tasks, derived from practice, to schooled and unschooled children or adults gives insight into the effect of schooling on cognitive development. For children involved in economic activity, like Saxe’s candy sellers, two systems of arithmetic exist and function independently. These are oral practices based on regrouping and counting strategies and written practices based on school-learned algorithms. The oral practices are actually more meaningful and less prone to error than the rule-based algorithms (Saxe, 1991; Stigler & Baranes, 1988). Adults use different strategies for school-type word problems than for mathematical tasks of everyday activity (Lave, 1988). Differences in performance between schooled and unschooled individuals on similar tasks seem to reflect an important contextual basis to all learning rather than the traditional view of an abstract, generalised reasoning developed in school and transferred to other contexts.
Saxe (1991) is also interested in how the mathematics of the classroom and the mathematics of selling practice interact. Schooled sellers use paper-and-pencil algorithms more than unschooled sellers; unschooled sellers always link their arithmetic to the currency system. With schooling there is an interweaving of practice-linked and school-linked strategies. Sellers were more adept than non-sellers at solving school-linked arithmetic problems; this was due to their knowledge of regrouping. Saxe concludes that transfer of learning does occur across contexts but is a protracted process and requires contexts (like schooling and candy selling) in which knowledge is well learned and in which similar problems emerge on a repeated basis.

In summary, research in cognitive science indicates that transfer of learning from one context to another is much more difficult than once assumed. Successful problem-solving requires a knowledge base; it does not depend primarily on superior reasoning ability which can be applied in any context. Further research on learning has supported Piaget’s constructivist perspective that learning is an active process and that people integrate new knowledge with what they already know. The research also suggests a significant role for instruction and for social support in learning.

Research in Mathematics Education

Research by mathematics educators is more interventionist than that of psychologists. The latter are primarily concerned with observing and describing what happens when subjects attempt cognitive tasks in order to develop theoretical models. Mathematics educators, on the other hand, are interested in effective ways to facilitate learning.

Teaching experiments and arithmetic word problems.

Researchers in both cognitive psychology and mathematics education use detailed analyses of thinking-aloud protocols. Subjects are encouraged to think out loud while they are doing a task. Their actions, written work, expressed thoughts, and explanations are used to make inferences about what they think and how they learn. To this end they have evolved the “teaching experiment” as an extension of Piaget’s clinical interview. In a teaching experiment, the teacher provides an occasion for the child’s mathematical thinking and then seeks to understand the actions and abstractions of the
child as he/she makes sense of the situation. The teacher may guide the child’s thinking in the process.

The bulk of this type of research in mathematics education has been on the development of whole number addition and subtraction concepts and skills as reflected in children’s solutions to different types of word “problems.” These try to capture the range of addition and subtraction situations which occur outside school. It has been found that children progress from modeling with concrete objects to counting-on procedures with fingers to using number facts. They use a variety of methods, depending on availability of objects, problem phrasing, particular numbers, and instruction they have been given. Although multiplication and division have been studied less than addition and subtraction, the research indicates that children have difficulty when these operations are extended beyond the whole numbers. They often believe that multiplication must make a number bigger and that division requires the larger number to be divided by the smaller. It is only after school instruction that many children stop eliciting meaning, make incomprehensible errors, and are unconcerned about nonsensical answers. Older students, even elementary school teachers, often solve a word problem without representing it in any meaningful way. Instead, they develop a mathematical expression on the basis of surface, syntactical clues (Fuson, 1992; Greer, 1992).

"Buggy" algorithms.

Another method used to infer children’s thinking is based on errors they make while performing mathematical tasks. This has been investigated most thoroughly for the subtraction algorithm (Brown & Burton, 1978); some work has also been done with algebra errors (Maurer, 1987). This research has found that children often have “buggy” algorithms; rather than not learning a particular concept or skill they have mis-learned it: They produce incorrect answers by consistently applying an incorrect idea or procedure. This seems to arise from overgeneralising what they already know. Diagnosing "bugs" and trying to explain their causes helps researchers build models of covert and unarticulated cognitive processes. Computer programs have been written that make the same errors as students; other programs can diagnose which bugs a particular student has (Maurer, 1987). Before students with a bug can learn the correct algorithm they must be “debugged.” It will not be very helpful to
explain the concept or procedure again. But if the bug can be identified it could be relatively easy to “fix” it; the student could be just a “bug away from having it all right.”

Problem-solving research.

Much of cognitive research in mathematics education has focused on how to help students become better problem-solvers. In the following discussion, a problem is taken to be a new and unfamiliar task for which relevant solution methods are not explicitly known, as opposed to the kind of routine exercises common in mathematics textbooks. Initially mathematics educators stressed problem-solving strategies or “heuristics” based on the work of Polya (1957, 1981). Heuristic strategies are general suggestions (for example, draw a diagram, specialise, vary the problem, work backwards) designed to help a student understand a problem and make progress, especially when “stuck.” Although there have been many attempts to teach students these generic approaches, the results have been disappointing. It seems the strategies were too simply defined and that their effective use requires not only mathematical knowledge but a metaknowledge of how and when to access the knowledge (Schoenfeld, 1985). As developed by Polya, problem-solving strategies are techniques used by good problem-solvers when they need to make progress on tasks that are challenging to them.

When differences between the problem-solving approaches of professional mathematicians and first-year university students are analysed, the major difference is that experts plan, monitor, and check their work—they have an internal dialogue as they work; they argue with themselves. This means that they not only access the mathematical resources at their disposal better than novices but that they avoid going on “wild goose chases”—a behaviour typical of novice problem-solvers (Schoenfeld, 1985). Later research (Lester, 1989; Schoenfeld, 1992) explores the explicit teaching of metacognitive strategies along with heuristic strategies in a classroom context. This has provided some evidence that metacognitive skills can be learned from instruction and that this leads to problem-solving success. The instruction takes the form of “coaching” with active interventions (“What are you doing? Why are you doing it? How does it help you?”) as the students work on problems in small groups, modeling metacognitive
behaviour, and discussing alternative solutions and strategies. It is more useful to discuss the problem after it has been solved by students than before.

Research on problem-solving carried out by mathematics educators supports other problem-solving research in pointing to an important contextual basis to learning; teaching general heuristic strategies has not proven to be very effective. There seems to be more promise in trying to teach the strategies along with metacognitive skills, while working lots of problems, in the context of the mathematics curriculum.

In summary, research in mathematics education lends further support to the constructivist view that individuals approach a new task with prior knowledge and assimilate new information by integrating it with what they already know. They may bring misconceptions and misunderstood facts to problem situations and are likely to accept new ideas only when their old ideas do not work or are inefficient. This constructivist perspective now dominates discussion in mathematics education and is having a major influence on mathematics curriculum. In this view, it is very important to find out what students already know and to use this to design learning activities which allow them to "construct" their own understanding and/or confront their misconceptions. The role of the teacher envisaged by constructivists is that of a facilitator and stimulator of student learning, posing interesting questions and situations for investigation, challenging students to think, and helping them uncover errors in their thinking.

Research on Ethnomathematics

D'Ambrosio, of Sao Paulo, Brazil, has spearheaded the ethnomathematics "movement." He became frustrated by the prevailing Eurocentric view while studying the history and philosophy of mathematics. He maintains that anthropological and "situated cognition" work shows evidence of typically mathematical practices done by cultural groups in radically different ways from what is commonly taught in the school system. A cultural group here is broadly defined. It could be a national-tribal society, a labour group such as carpenters or tailors, or children of a certain age.

D'Ambrosio advocates a research program, using both cognitive theory and cultural anthropology, to trace the origin of the mathematical practices of such cultural groups. He has labelled this "ethnomathematics" to distinguish it from the mathematics taught and learned in schools, which is based on
Western thought and use (D'Ambrosio, 1985). Thus, research in ethnomathematics includes “situated cognition” studies in Western, non-Western, and aboriginal cultures, as well as the identification of mathematical ideas that are indigenous to these cultures but not part of the established curriculum. From the data on mathematical practices of culturally identifiable groups, D'Ambrosio thinks it will be possible to discern patterns of reasoning and so establish these ideas as a structured body of knowledge rather than just sets of ad hoc practices (D'Ambrosio, 1985).

Ascher (1991) has written about mathematical ideas on number, logic, and spatial configurations in various traditional cultures. These include the knotted strings (quipus) of the Incas; the sand-tracings of the Malekula of the New Hebrides; the Bushoong of Zaire and the Tshokwe of Angola; kinship relations of indigenous Australians; strip patterns of the Incas and Maori; spatial ideas of navigators in the Caroline Islands, the Navajo and Inuit; and games of chance and strategy of native Americans, Maori, and Africans. She maintains that there is an interplay of mathematical ideas and culture. Which ideas are emphasised, how they are expressed, and the particular context, vary from culture to culture. She believes that, in addition to broadening the history of mathematics to include traditional, non-Western cultures, the study of ethnomathematics should force a change in emphasis so that Western expression is not a measure or standard of comparison for other ideas.

Zaslavsky (1973) has documented mathematical ideas about number, measurement, design, and games in cultures of sub-Saharan Africa. Finger gestures to describe numbers are common in Africa. This is probably due to the multiplicity of languages. Societies involved in commerce have developed more extensive number systems and more elaborate systems of weights and measures than societies which do not trade. An example of a well-developed system of standard measures is the Asante bronze weights for measuring gold dust. These are fashioned in the form of figurines, objects, or geometric shapes. Articles of everyday life like baskets, mats, and cloth are decorated with characteristic designs which exhibit well-known mathematical symmetries. Zaslavsky discusses the architecture of Great Zimbabwe and mathematical games played by Shona children. The universal African game of transferring, played in different versions throughout Africa and other parts of the world (tsoro in Zimbabwe), is considered among the world’s best games.
of strategy. Unquestionably, mathematics exists in the indigenous practices of Africans.

Zaslavsky’s book was one of the first ethnomathematical works. An American, she was interested in helping Africans to “reclaim their heritage.” She searched the mostly European literature and checked the information with students of corresponding ethnic backgrounds attending universities in America. She also visited East Africa and southwest Nigeria to interview scholars and students there.

Gerdes, a mathematics educator in Mozambique, has written extensively of mathematical ideas in Angola and Mozambique. He has examined traditional objects in Mozambique such as baskets, mats, pots, houses, and fishtraps to uncover “hidden” geometric ideas (Gerdes, 1985). He has also analysed the sand paintings done by the Tshokwe in Angola using graph theory (Gerdes, 1988a). One of his objectives is to make student teachers in Mozambique more aware of mathematical aspects of their own culture. Teachers could use this knowledge to introduce related concepts in the curriculum (Gerdes, 1985, 1988b).

Research on Cooperative Learning in Mathematics

Cooperative learning is a generic term used to describe small groups of students sharing ideas while working together to accomplish academic tasks. It is sometimes difficult to interpret research results on cooperative learning because of the diversity of studies (different subjects, different models of cooperative learning, different research traditions, different theoretical bases). Nevertheless, there is consistent evidence, for all school subjects, that learning in cooperative small groups can increase achievement (Bossert, 1988; Slavin, 1989/1990, 1995). Less than half of the studies comparing small group methods and “traditional” methods in mathematics classes find significant differences in achievement, but these all favour cooperative learning (Davidson & Kroll, 1991). The methods have been shown to facilitate the attainment of affective as well as cognitive goals and outcomes (Bossert, 1988; Good, Reys, Grouws, & Mulyran, 1989/1990; Slavin, 1989/1990, 1995). In mathematics, they have been used for both mastery of specific learning outcomes and development of higher order thinking skills. Affective goals include motivation to learn and acceptance of others, as well as improvement of social and communication skills.
Exactly why and under what conditions cooperative learning is effective is not clear. The positive effects have been attributed to peer encouragement, cognitive processing, constructive controversy, and social collaboration (Bossert, 1988; Yackel, Cobb, & Wood, 1991). Support from peers can lead to enhanced involvement in learning. Giving and receiving task-related explanations facilitates integration of information. Discussion of controversial ideas requires accommodation to the ideas and opinions of others. Working with more capable peers can help students accomplish tasks they might not be able to do alone. All of these theoretical explanations are predicated on social interactions among students.

Because most cooperative learning studies measure engagement by time on task they give little insight into group processes. A few studies, though, have explicitly considered the interactions which take place among students working together. Webb (1991) found that students who provided explanations to others made the greatest gains in academic achievement. Yackel, Cobb, & Wood (1991) analysed examples of small group interactions in a second grade mathematics classroom and concluded that learning results as much from collaborative dialogue as resolution of conflicting points of view. Slavin (1995) maintains that students are motivated to learn when group goals and individual accountability are built into the task structure. Group success must depend on all group members’ effort. If not, high ability students often control the group or want to work alone. If they are not held accountable as individuals, passive students are often content to let others do the work (Good, et al., 1989/1990; Good, Mulyran, & McCaslin, 1992). Whereas researchers agree on individual accountability they disagree about the need for extrinsic group rewards, constructivists maintaining that the educational benefits are intrinsic to the interaction. Webb (1991) points out little is known about the thinking of passive students because interaction studies focus on student dialogue.

Despite convincing endorsement by the research, most mathematics teachers do not use small group methods. This may be due in part to a lack of appropriate and readily available curriculum materials (Good et al., 1989/1990; Noddings, 1989/1990). Discovery learning, laboratory investigation and data collection, group discussion of concepts, and problem-solving, (as well as practice of skills) can all be used in conjunction with cooperative learning (Davidson, 1985). In the absence of extrinsic rewards, activities
designed to be problematic for children at a variety of conceptual levels are crucial for creating a cooperative learning environment (Yackel, Cobb, & Wood, 1991). Conceptual and problem-solving tasks that are moderately difficult and allow for more than one approach to solution have the most potential for stimulating children to articulate their thoughts (Good, et al., 1992). In mathematics, selecting appropriate curricular tasks is critical to the success of cooperative small group methods.

Research on the Use of Technology in Mathematics Teaching

There is extensive evidence that the heavy use of calculators in the early grades as part of instruction and assessment does not harm computational ability, and enhances concept development and problem-solving skills (Fey, 1989; Hembree & Dessart, 1986). In a meta-analysis of 79 studies involving students from kindergarten to grade twelve, Hembree and Dessart found that, at all grades but grade four, use of calculators in concert with traditional mathematics instruction improved the average students' basic skills with paper and pencil, both in working routine exercises and in problem-solving. Paper and pencil skills of low and high ability students remained at par with those in control groups. Across all grades and ability levels, students using calculators possessed a better attitude towards mathematics and a better self-concept in mathematics than students not using the calculators. Fey (1989) comments that despite this research, and despite the fact that calculator and computer-aided numerical methods are standard tools in mathematical work at all levels, there remains considerable controversy in schools about the potential impact of calculator use on basic skills. Tradition dictates the use of the tools only after students have acquired proficiency with paper and pencil procedures. As a result, most research has focused on the possibility of harming basic skills; less has been directed at how calculators can actually be used to enhance achievement. Similarly, there is evidence that work with scientific calculators and graphing utilities has a positive impact on students' conceptual learning without loss of symbolic computational skills (Fey, 1989; Kaput, 1992).

Kaput (1994) suggests several advantages for using calculators and computers for learning mathematics. Applications in texts are often very contrived; technology allows the investigation of more realistic examples because routine and complicated calculations are no longer a problem. More
experience with the concepts can be gained in the same amount of time using calculators and computers than without. A computer can be used to create a variety of representations for mathematical ideas and methods, and to show how they are related. The consequences of an action in one representation can be shown in another. Dynamic media like the computer can give a deeper understanding of the key idea of a variable, providing a better foundation for calculus. There is great potential for using computer graphics to give visual representations for abstract mathematical ideas.

Some Approaches to Curriculum Arising out of Research

Current calls for reform in mathematics education focus more on teaching than content. Recommendations for teaching have originated from cognitive research on learning and problem-solving and reflect a constructivist paradigm. An example of constructivist philosophy translated into curriculum are the NCTM (National Council of Teachers of Mathematics) Standards documents. The Standards reflect a consensus among the membership of the NCTM and the broader education, scientific, and business communities as to what a high-quality mathematics education for North American students, K-12, should comprise. They are meant to provide guidance to those involved in changing mathematics teaching (NCTM, 1989) and are having an impact outside of North America as well as within. Both the Zimbabwe mathematics syllabus and the NCTM Standards curriculum documents share some common constructivist themes (problem-solving, use of concrete examples and applications, activity-based learning, cooperative small group work, acknowledgement of the cultural basis of mathematics, connections to other content areas, and communication of mathematical ideas) which are current in the international mathematics education community.

The availability of calculators and symbol manipulation computer programs that can deal with nearly any situation appearing in secondary school and early university mathematics promises a change in focus from current emphasis on procedural details to greater emphasis on conceptual understanding and problem-solving. Calculators and computers are widely used outside the formal education system and they have affected how mathematics is done in the "real world." Nevertheless, despite considerable emphasis on technology, the NCTM Standards documents claim to present a
vision of school mathematics that is based on the fundamental mathematics students will need, not just on technological training that will facilitate the use of that mathematics. Calculators and computers, like word processors, are tools that simplify, but do not accomplish the work at hand (NCTM, 1989).

D'Ambrosio (1985) suggests that students react badly to mathematics in school because they find it remote from their own concerns and environment. He thinks that perhaps ethnomathematics can bridge the gap. Ethnomathematics has the potential for providing a context which will engage learners; a starting point for doing mathematics in the classroom. This can serve as cultural affirmation, creating confidence in students' ability to understand, use, and develop mathematics. In a constructivist view, it can also contribute to more effective learning by linking what the children know out of school to what they learn in school.

Bishop (1991) advocates an innovative approach to curriculum design which he describes as "mathematical enculturation." In his analysis he has drawn extensively on the growing body of knowledge about ethnomathematics. He suggests that a universal set of activities have fostered the development of mathematics everywhere and that these should form the basis of a child's mathematical education. His six universal activities are counting, locating, measuring, designing, playing, and explaining. He suggests that all the important concepts of mathematics taught at elementary and secondary school can be incorporated into this framework and introduced through suitable activities. All cultures count, locate, measure, design, play and explain. Focusing on mathematics as a cultural activity implies that curriculum in different countries could be quite different while still reflecting the same broad perspectives. Also, examining these activities in other cultures would broaden and deepen mathematical understanding. Bishop feels that emphasis should be on providing a "mathematical education for all" rather than "teaching mathematics to all."

Howson and Wilson (1986) maintain that the extraordinary uniformity of syllabuses across the world seriously inhibits significant change in school mathematics. They refer to the "canonical mathematics curriculum," pointing out that the school mathematics curriculum was developed in a particular historical and cultural context, that of Western Europe in the aftermath of the Industrial Revolution. Subsequently, what began as an education for a small elite was extended to all (in Europe) and exported.
around the world. While encouraging international exchange of information, ideas, and research findings, even of materials, Howson and Wilson urge curriculum developers to make their own needs a higher priority than considerations of international “standards” and issues of comparability.

Evaluation of Proposed Changes to Mathematics Teaching for the Zimbabwean Context

Are concrete, contextual, activity-based learning, cooperative learning, and an emphasis on problem-solving important changes to implement in Zimbabwean secondary schools? Will they address concerns about mathematics teaching and learning expressed by educators there? The following discussion examines the current reform agenda, including recommendations for teaching in the 1991 Zimbabwean O-level syllabus, in light of Fullan’s three criteria for worthwhile educational changes: are they needed? are they technically sound? are they feasible in the circumstances?

Are They Needed?

Based on interviews with mathematics and science educators in the SADCC region, Macfarlane, et al. (1990) claim that there is too little practical work or hands-on experience in the average mathematics and science lesson and that teaching methods should stimulate pupils to be more active in the learning process. They stress that the most urgent manpower needs in the region are in the areas of science and technology and argue that improving mathematics and science teaching at the secondary level is a precondition for successful post-secondary training. When Jaji (1990) asked teachers to identify the major approaches they used to help their pupils learn mathematics, chalkboard explanations and lots of practice work were reported most often. She argues (Jaji, 1993) that teachers must move to more constructivist approaches if they are to implement the intent of the syllabus. Some educators in the region, then, feel that more active learning and constructivist approaches to teaching are necessary to provide students with the requisite knowledge and skills to participate in the economy.

Wilson (1992), in a review of mathematics education in Africa, points out that many African countries are concerned about falling standards in examination results which is more marked in mathematics than other subjects. He maintains that pupils are doomed from Form One to fail in an
examination which is deliberately designed to be too difficult for them. Secondary school systems in Africa were originally established to cater for a small minority of the population and highly competitive academic selection procedures ensured that these pupils were drawn from the top quartile of the ability range. These are the students for whom O-level examinations were designed. The fundamental cause of poor examination results, then, is that expansion in secondary education has reached a point where the examination is no longer appropriate for the majority of pupils entering the secondary schools. This analysis certainly pertains to Zimbabwe where expansion of the secondary school system since independence in 1980 has been more rapid and greater in magnitude than anywhere else in Africa. In fact, during the colonial era, due to the highly selected intake in African secondary schools, Zimbabwe had for many years the highest pass rate in the world among countries that wrote the O-level examination (Dorsey, 1989).

Howson and Wilson (1986) discuss common approaches to differentiation of curriculum. When there is no differentiation, the better students reach a high standard and all students are seen to have had equal opportunity. However, many students, understanding little, lose interest in mathematics. Teaching then becomes more difficult. When differentiation is practised by traditional means such as different schools, different programs within a school, streaming by ability or achievement, or individualisation of instruction, more students are successful. However, the selection process is always problematic. Low achievers are labelled as such, introducing a self-fulfilling prophecy, and schools reinforce, rather than mitigate, social and economic disparities.

The current reform agenda advocates "mathematics for all" through a core approach to curriculum. A core curriculum would expose all students to the same topics and the same instructional practices and resources. It would differentiate in the depth and breadth of treatment and in the nature of applications. Both the Cockcroft Report (Cockcroft, 1982) in Britain and the NCTM Standards (NCTM, 1989) in the United States recommend this approach to differentiation of curriculum, along with changes in assessment practices.

A recurring theme of assessment reform is that a change in public assessment is the key to wider change in curriculum and pedagogy. Howson and Wilson (1986) point out that external examinations have been introduced
largely in an attempt to control teachers and teaching. Examinations set standards, preserve uniformity, and provide teachers and students with common goals. However, they also limit the curriculum with regard to both content and teaching methods. Reviewing three recent collections of papers on assessment in mathematics education (primarily from English-speaking countries), Ruthven (1994) identifies two major trends of the current agenda for assessment reform: to integrate teaching, learning, and assessment, and to make assessment tasks correspond more closely to mathematics as it is practised. Implementing these changes means, however, that at least some part of formal assessment must take place at the classroom level.

Hammersley (1990) questions the common wisdom that examination systems are responsible for instructional practices and argues that even in the absence of external examinations, teaching is heavily influenced by traditional assessment techniques. He found that teacher behaviour, as measured by teacher and pupil talk, did not differ much in examination courses and courses with coursework assessment or no assessment. In British Columbia, Canada, a teacher assessment component contributes 60% to the final grade. Teachers there tend to model their assessment procedures on the provincial examination, seeking a positive correlation between teacher and examination marks, which actually negates the intent of the teacher assessment (O'Shea, 1992). Ruthven (1994) points out that the British GCSE examinations, which originally moved the system of assessment in exactly the directions being advocated by reformers, actually amplified group differences and suggests this could be due to differing home and community backgrounds and to greater familiarity with the language of instruction for some students than others. Thus, it is possible that changing public assessment may not have the impact desired, particularly in promoting "mathematics for all."

There are many difficulties pertaining to language inherent in teaching mathematics even when both teachers and students are fluent in the language of instruction. This intrinsic difficulty is compounded in most African countries by two factors. First, the mother tongue may lack words for some of the concepts. Second, at mid-primary in most of sub-Saharan Africa, a colonial language replaces an African language as the language of instruction. As children go through a process of inner translation, the instructional process becomes focused on words rather than the concepts the
words are intended to convey. This is particularly problematic in mathematics where missing a concept makes it difficult to progress. Wilson (1992) maintains that this language-based difficulty is a major factor contributing to levels of failure in mathematics in African schools. In Zimbabwe, the mother tongue of the majority of African children is either Ndebele or Shona and these languages are widely spoken both in and out of school. In Form One many children, particularly in rural and high density areas, are not yet fluent in English, the language of instruction.

Fullan (1991) suggests there is often a "bias of neglect" regarding needed changes that are not proposed. The Zimbabwean context is different socially and culturally from the contexts in which most research on learning has occurred and proposals for change have originated. Its educational institutions have evolved in a unique set of historical circumstances. In Zimbabwe any analysis of the need for educational change in the teaching and learning of mathematics must consider curriculum, assessment, and language issues, along with teaching methods.

Are They Technically Sound?

Constructivism is having a strong impact on the thinking of mathematics educators around the world. Constructivists have sought to derive implications for practice from their theory; for example, that students' previous knowledge be considered, that teaching be highly interactive, that situations and objects be used to stimulate reflective abstraction or cognitive dissonance, and that learning develop out of problem situations. Noddings (1989/1990) maintains that paradigm differences about what it means to do mathematics create a false dichotomy between "traditional" methods of teaching and "constructivist" methods of teaching and that, if the concern is to improve practice, mathematics educators need to move beyond this controversy. The bulk of learning research is based on one-to-one or small group teaching with students working on particular tasks. In contrast, teachers work with large groups of students learning over time and must consider a myriad of factors when planning instruction (Brophy, 1986). However useful it might be to individual teachers reflecting on practice, constructivism is still a theoretical construct not a blueprint for change (Kilpatrick, 1987; Noddings, 1989/1990).
Concrete, activity-based learning was one of the first applications of Piagetian theory to instruction and there are now well-developed ways to teach basic number concepts and skills using these methods. Other curriculum areas have not received as much attention. Although cooperative learning, like Piagetian theory, has been around for a long time, it has been researched and practised less in mathematics teaching than in other subjects. Good curriculum materials to support teachers are not readily available (Good, et al., 1989/1990; Noddings, 1989/1990). Low achievers do not seem to benefit as much as other students from cooperative methods; understanding better how interactions in small groups facilitate learning may help teachers develop strategies to involve these learners (Good, et al., 1989/1990; Webb, 1991). There has been far more rhetoric than substance over the last two decades about making problem solving the focus of the curriculum. Despite the promise of modeling, metacognitive instruction, and small group work as useful approaches to teaching problem solving, the promise is as yet unrealised. Although agreement exists on the need to capitalise on the informal mathematics that children bring to instruction, exactly how this should be done is still open to question (Wilson, 1992). Does using calculators interfere with computational ability and understanding of number concepts; does using computers and scientific or graphing calculators interfere with numerical understanding of functions? There is some concern that the actions which are factored out when using technology are needed for full understanding of the concepts and that diminished command of traditional skills may have damaging effects for advanced study. Howson and Wilson (1986) regret that interest in computers has limited research into the use of calculators for teaching mathematical concepts. The suggestions are not technically sound, then, in the sense of being readily implementable in the classroom.

Are They Feasible in the Circumstances?

Howson and Wilson (1986) suggest that differential access to technology may be what finally shatters the hold of the canonical mathematics curriculum. For economic reasons, computers for classroom use in most schools are not feasible. A reasonable supply of calculators, on the other hand, is a possibility. Attitudes to their use in the schools amongst parents and teachers may be a greater barrier to their use than economics.
(Wilson, 1992). O'Shea (1996) suggests that the way to convince the public is through demands of employers and that textbooks must address the issue and provide support for teachers. The new edition of the Zimbabwe Form Two textbook, New General Mathematics 2 (1992) contains a chapter on calculator skills. The Zimbabwe syllabus version 4008 does not refer to technology; another version 4028 allows candidates to use calculators in paper 2 of the O-level examination.

There are several difficulties with the new vision of assessment. Reformers are more clear about what they want to move away from (assessments which provide poor models of mathematical activity and fail to provide information of formative pedagogical value) than what they want to move towards (Ruthven, 1994). Ruthven maintains that defensibility of new forms of assessment as appropriate and fair means of certification and selection will be critical to their acceptance by the public. Universal secondary schooling creates a dilemma at upper secondary where assessment has the explicit functions of both certification and selection. Assessment based on classroom practice gives teachers extra responsibilities and also requires that the public gives credence to the informed judgment of teachers. Attempts to introduce teacher assessment in countries without this tradition have not been particularly successful, for example, Tanzania (Saunders, 1982) and Sri Lanka (O'Shea, 1996). Assessment systems have to be realisable by the typical teacher in the typical classroom. O'Shea (1996) suggests that issues of selection should not be confounded with issues of certification and that the solution lies in designing examinations which better serve students at both ends of the ability spectrum. Whatever the difficulties, curriculum change is inextricably linked to methods of assessment. Ruthven (1994) notes that change in public assessment is not integral to the education system, yet reform depends on empowering teachers to create change where it really happens: in the classroom.

Howson et al. (1981) suggest that the most important lesson to be learned from the experience of the 1960s and 1970s is the central role teachers have to play in curriculum development, and that the best hope for improving mathematics teaching lies in the professional development of teachers through curriculum development work. Only national teachers (not even university lecturers) are aware of the practical realities of the school situation. The western authors of the Entebbe materials lacked any prior
understanding of the educational systems and of conditions in the schools. The mass dissemination strategy used for Entebbe mathematics and SMEA (in contrast to the school-based model for SMP in the UK) did not work. The fact that the programs were unproblematic in "equivalency" schools but unsuccessful in "low-status" schools with differing resources, pupil intake, and teacher expertise invites the question as to exactly why they were unsuccessful. Were the teaching methods even implemented in any of the schools? Maravanyika (1990) suggests that indiscriminately selected and poorly motivated teachers are not good agents for reform. Lillis (1985) suggests an initial adopter group familiar with the proposed changes working in the schools may have made a difference.

Maravanyika (1990), in reviewing literature on educational policies in sub-Saharan Africa, acknowledges Fullan's conclusion that reforms which entail new teaching strategies and altered role relationships in the classroom are the most difficult to implement. This has been one of the most powerful lessons of 30 years of planned educational change in North America and it is a lesson which seems to be confirmed by the experience in Africa of the mathematics programs of the 1960s. Fullan (1991) claims the difficulty of learning new skills and behaviour and unlearning old ones has been vastly underestimated. Like those of SMEA, the kind of reforms being advocated for teaching of mathematics and science in Southern Africa, including Zimbabwe's mathematics syllabus, are ones which involve changes in the role relationship between teachers and students and, as such, will not be easy to make. The following chapter explains how some of Fullan's ideas about effective educational change have been incorporated into the design of this study.
Chapter Three
Methodology

This chapter describes how the study was conducted, making reference to the literature on qualitative research and educational change which both informed the design of the study.

Advantages of Ethnographic Methods for Research in Education

The strength of ethnographic educational research is that it explicitly acknowledges that education is a complex endeavour set in a broader sociocultural milieu and that people's behaviour can only be understood in that broader context. Because people interpret situations and give meaning to them, explanations of behaviour must consider individual perspectives. Ethnographic methods such as participant observation and in-depth interviewing allow researchers to interact with teachers and students in their natural setting (classroom, school, and community) and come to know those perspectives.

By recognising that the interaction of researchers will affect what happens in a setting, ethnographic methods foster reflective inquiry by both the researcher and participants. The researcher as participant observer is both an insider and an outsider. As an insider, s/he can come to appreciate and so describe the situation from the perspective of participants. In the process s/he will also have to confront his/her own preconceptions and misconceptions. On the other hand, as an outsider, the researcher has a perspective not available to other participants. Members of a culture are rarely conscious of fundamental assumptions underlying their own thought and behaviour. The presence of the researcher can stimulate other participants to examine some of their assumptions. Critical self reflection by both researcher and participants has the potential to provide fresh insight and new conceptualisations (Eisenhart, 1988; Goetz & LeCompte, 1984; Hammersley & Atkinson, 1983).

The potential of ethnographic research to generate hypotheses and theories is facilitated by the flexibility of the approach. Rather than impose a predetermined and possibly inappropriate framework on the research, methods can be changed during the course of fieldwork in response to growing understanding or unforeseen circumstances. Analysis occurs
simultaneously with the data collection. As a result, initial exploration and
description can lead to testing of hypotheses or reformulation of issues.

Ethnographic methods are appropriate for this study because the intent
is to understand what influences the practice of teachers, and, possibly, change
that practice. Evaluation research of curriculum reform in the 1960s revealed
many unintended consequences but it did not adequately explain the success
or failure of programs. Neither Western nor African educators nor African
policy-makers appreciated sufficiently the importance of context when the
new and modern mathematics curricula were introduced into Africa.
Subsequent implementation studies in countries of sub-Saharan Africa have
usually been accomplished through either surveys or brief school visits.
These are more likely to produce the rhetoric than the reality of reform
and found that what teachers said about their practice did not match the aims
and methodology of the syllabus. But why is there this lack of congruence,
and if change is desirable, how should it happen? Ethnographic research, with
its emphasis on context, understanding the perspectives of participants, and
generation of theory, has the potential to address these kinds of questions.

Little has been written about the conduct of educational research in
countries of the South, particularly that which focuses on classroom practice.
Exceptions are Avalos' (1986) study of school failure among poor children in
South America, Crossley's (1984) and Vulliamy's evaluation of community
projects and village out-stations as part of the curriculum in secondary
schools in Papua New Guinea, Lewin's research on science curriculum in
Malaysia and Sri Lanka (Vulliamy, Lewin, & Stephens, 1990), and the action
research (Collaborative Action Research in Teacher Education (CARE) of
teachers and teacher educators in Sierra Leone (Wright, 1988a, 1988b). This
work indicates the potential of ethnographic methods to contribute to practice
and policy-making and to the establishment of a stronger educational
research base within these countries.

The projects mentioned in the previous paragraph all involved
partnerships between local and overseas researchers. Such partnerships,
however, can be problematic. Crossley (1984) argues that models of change
strategies are now being exported, just as curriculum changes were in the
1960s and 1970s. School-centred innovation has become the new panacea for
the problems of curriculum development and educational change but there is
a shortage of empirically grounded evidence to substantiate the claims of advocates of this approach, (Crossley, 1984; Dzvimbo, 1994; Fullan, 1993; Hargreaves, 1982; Wright, 1988b). My study should provide additional insight into the feasibility and value of school-based innovation in an African context as well as into the role of expatriate researchers and organisations in effecting change.

In the CARE research, teacher educators at a local teachers' college and practising teachers wanted to improve the situation in the schools, as well as develop better teacher education programs. They intended to bring about constructive changes in educational policy and practice through the research process itself. The CARE research, with its emphasis on collaboration and action, is closest to the design of my study. Researchers concluded that action-oriented research as a strategy for changing educational practice had significant limitations, although they found that CARE did enhance the professional outlook and competence of teachers. Although some outcomes had a direct impact on practice, genuine collaboration was difficult to achieve. (Wright, 1988a). I had the same motivation as CARE. By using ethnographic methods and by grounding my study in current theory of educational change, I hoped to bring about constructive change in practice through the research process.

How the Literature of Educational Change Influenced the Study

Ideas expressed in Fullan's (1991) book on the meaning of educational change have been especially influential in the design of this study. Fullan has attempted to distil from the literature important lessons about how to cope with and influence educational change. He tries to explain why change processes work as they do and identify what we might do to get better at change. Although most of the material he draws on comes from attempts at educational reform in Canada and the United States, some studies from other countries as well as personal contact with other educators leads him to believe that the nature of problems and many of the principles of success and failure have much in common everywhere. Many of his conclusions are supported by the experience with mathematics curricula in Africa which is described in Chapter 2. He maintains that particular actions in particular situations require integrating general knowledge of change with detailed knowledge of the setting in question (Fullan, 1991). In designing this study I
tried to integrate what I knew of mathematics teaching and learning in Zimbabwe with general principles from Fullan's work which seemed to apply in the African and Zimbabwean context.

**Importance of Individual Initiative along with Personal Contact and Collaboration**

According to Fullan (1991), change requires supporting people who are acting in purposeful ways. It is the actions of individuals, working together, which make a difference. "Changes in educational beliefs, teaching styles and other practices represent profound changes affecting the teacher's professional self-definition" (Fullan, 1991, p. 129). The key to helping teachers make these profound changes is collaboration. Previous curriculum change in mathematics, in Africa and elsewhere, has not been particularly effective, even when supported with in-service holiday workshops. My own experience with the CTF/ZIMTA holiday workshops had made me question the effectiveness of such approaches; my reading about the implementation of the new and modern mathematics curriculum confirmed that I was right to do so. The literature reviewed by Fullan affirms that personal contact at the school level is critical to success at change efforts.

My role in this study was that of a participant observer, actively involved in classroom teaching, along with other mathematics teachers in the same school. My previous teaching experience at the mission school and at the teachers' college meant that I was much more familiar with the educational system and conditions in the schools than I had been in 1984 when I arrived in Zimbabwe with the CTF. Because of my experience at GTC, I wanted to make a difference, and I now had colleagues at the teachers' college and contacts at the regional office of the Ministry who were also interested in working with teachers to improve the teaching of mathematics.

The WUSC associate program, which was financing my project, was designed to support individuals who were in a position to make a difference because of their unique experience and background. WUSC had an established relationship with the Ministry of Education and Culture (MEC). The organisation had recruited Canadian secondary school teachers for Zimbabwe since independence. It also funded small projects in the schools and provided bursaries for girls at A-level. WUSC and the Ministry had recently collaborated in offering workshops for headmasters to promote the
"cluster" concept. The idea was to encourage schools in the same geographical area to cooperate in local initiatives to improve education. On my return to Zimbabwe in 1993, I met with the Chief Education Officer, Standards Control, in Harare. She was quite positive about the project and talked to me about the cluster concept. She provided me with a letter of support to take to the regional office and encouraged me to try to establish a local resource centre.

Administrators are an important source of advocacy and support for change. According to Maravanyika (1990), African administrators have bemoaned teachers' incapacity to put reforms into effect, yet have seldom taken appropriate steps to address the problem. Bureaucrats and administrators often emphasise adherence to routine rather than results. Also, as it is difficult to obtain vehicles for travel, Ministry officials are not always in touch with what is happening in the schools. In Zimbabwe, political urgency to redress inequalities in education has made it difficult for administrators to provide adequate support for teachers (Dorsey, 1987). But, teachers do not take change seriously unless administrators demonstrate through concrete actions that they should. For effective change, administrators need to reflect an understanding of the change process, show an active interest, and provide both psychological and material support for teachers (Fullan, 1991).

My previous relationship with the mathematics education officer (EO) at the regional office was critical to the design of the project. Throughout the study, he helped to validate my role. I wrote from Canada, sending the proposal for my study and requesting assistance in choosing a school with a supportive principal and teachers who were willing to work with me. When I arrived at regional office, with my letter of support from head office, I found that he had already chosen a school which fit my proposal description as a school in a high density area with teachers trained at secondary teachers' colleges. It had a cooperative, well-functioning mathematics department and he had confidence in both the headmaster and the head of department (HOD). We visited the school the following day; they were expecting me. Although I had planned that the teachers would volunteer for the project, this was not exactly what happened; rather, they agreed to help me at the request of the education officer and headmaster. I came to realise that they could not have said "no" to such a request, even though they knew little about the project. It
was clear, though, that I had the support of the Ministry through the mathematics education officer.

Reflective Practice

Schon's (1983) analysis of what it means to be professional develops the concept of professionals as reflective practitioners. "Reflection in action" has become the basis of an alternative paradigm for educational research. The primary purpose of this kind of research is to improve practice. Research by teachers can simultaneously test hypotheses, effect desired change, and serve as a source of professional renewal (Kemmis & McTaggart, 1988). Fullan (1991) maintains that in order to get better at change we have to practice it on purpose. It is only by trying something that we will find out if it works. The more teachers interact concerning their own practice, the more they will be able to bring about improvements and grow professionally.

I wanted to change my own practice and to influence the practice of others. The research design was intended to encourage interaction, reflective practice, and professional growth. I took one class from each of four teachers, so we all had four classes instead of the usual five. Teachers usually taught several classes of the same form so this meant that I shared a form with each of the teachers. This maximised the potential for interaction. Also, with one less class, all of us had more time for preparation and for thinking and talking about what we were doing. The original design also included observations of each other's lessons, but in practice, this did not materialise. (I did observe the other teachers' lessons, but this was done during the first term of 1994, when I was not teaching.) My field notes included critical reflection on my own teaching. I had hoped to convince the teachers to keep a journal, but this also proved to be impractical.

Need to Understand the Subjective World of Participants in the Change Process

Change is a highly personal experience. Everyone affected by change must have the opportunity to work through the experience in a way in which the rewards at least equal the costs for them (Fullan, 1991). A powerful lesson of the last thirty years of educational change is that all participants need to appreciate the change process and to understand it from alternative perspectives. If governments, administrators, parents and local communities, students, and teachers are ignorant of each other's subjective world, reforms
will fail. In particular, community expectations are a powerful influence on change and on the perspectives of both teachers and students.

**Parents and local communities.**

Education is highly valued in African communities largely because it is seen as a way to escape from poverty and from the countryside to jobs in the modern sector of the economy which can provide a better standard of living (Dorsey, 1989; Maravanyika, 1990). Fullan (1991) notes that less educated communities are not as likely as highly educated ones to initiate change or to put pressure on educators to initiate changes on their behalf. However, local communities can transform curricular and pedagogical reforms by disorganised resistance. African parents have often resisted changes which purport to adapt schooling to the environment of a particular community (Maravanyika, 1990; Saunders, 1982; Wilson, 1992).

In Zimbabwe, the two year junior secondary (F2) schools introduced by the Rhodesian Front government were not accepted by the black community because it considered the vocational education they provided to be inferior (Dorsey, 1987). The Zimbabwe Foundation for Education with Production (ZIMFEP) schools established during the war and repatriated from Mozambique and Zambia onto commercial farms at independence failed in their role as model schools. Education with Production became more of a slogan than a meaningful educational philosophy; the majority of blacks were more interested in the kind of education they had been denied (Maravanyika, 1990). Many parents and teachers in Zimbabwe view the Zimbabwe Secondary Schools Science Project (Zim Sci) as second rate. Through the Ministry, ZimSci provides low cost equipment and "teacher proof" curricular materials to untrained teachers in rural schools without conventionally equipped laboratories. ZimSci and the following O-level core science were designed to provide a meaningful science education to the majority of students in Zimbabwe by deriving scientific principles from everyday reality. Hungwe (1994) maintains the rural poor have remained relatively quiet and the Ministry has not defended their needs in the debate surrounding ZimSci. Plans developed in 1979 for a new National Certificate for non-academic students were abandoned at independence (Atkinson, 1972). The issue surfaced again in 1987 in response to declining examination results and a differentiated curriculum was tried in some schools (Dorsey, 1989). At the
time of the study there was considerable debate about the merits of an alternative curriculum to O-level, particularly in mathematics.

Although the study did not specifically investigate attitudes among parents of children in the school, the perspective of the community was crucial to understanding the context of the study and the attitudes and behaviour of teachers and students. I used document analysis to provide this perspective. I saved newspaper articles, letters to the editor, and editorials about education which appeared in the Herald, the Chronicle and the Financial Gazette at the time of the study. I also collected issues of Teacher in Zimbabwe and Moto magazine from April, 1993 to February, 1994 and noted relevant articles. I photocopied minutes of staff and departmental meetings; these contained references to concerns of parents of the children in our school and to parental involvement in the school. The documents reflected the attitude of the larger community to education and also provided insight about social and political events at the time of the study. All documents were filed with my field notes.

Students.

Fullan (1991) maintains that we do not know what students think about educational change because we rarely ask them. Yet effective change in schools involves just as much cognitive and behavioural change for students as it does for anyone else. Fullan suggests that students' reactions to change can be either indifference, confusion, or heightened interest and engagement (the desired outcome). Educators should consider carefully how to introduce innovations to students and how to obtain their reactions.

Changes in the role relationship between students and teachers are the most difficult educational changes to make (Fullan, 1991). Some educators in southern Africa are advocating that students take a more active part in their lessons. Student teachers in Zimbabwe are being encouraged to foster pupils' learning through "pupil talk" as part of a curriculum project in the teachers' colleges funded by the British Council (Communication Skills in Teacher Education Project, 1994). A Botswana study (Fuller & Snyder, 1991) found students rarely speak up with queries of their own. Critics (Lillis, 1985) have attributed the "failure" of SMEA in rural schools in Kenya partly to implied teaching methods which depended on pupil discussion. Why are students quiet? Is it because teachers' methods discourage pupil talk? Is it because their
behaviour is influenced by cultural expectations: children are expected to listen and to respect authority? Is it because they are learning in a second language? Perhaps, like many students elsewhere, their interest in school has little to do with curriculum and classroom interaction. In North America, only a small number of students, those who are planning to attend a college or university, participate regularly in classroom discussions. Other students pay a minimal amount of attention to formal classroom work. Social interaction provides the major source of satisfaction at school for most students. One third of students leave school before graduation and one third of those remaining lead lives of uninspired passive learning (Fullan, 1991). Perhaps lack of involvement in classroom discourse is a natural consequence of universal education. Surely, the answers to these questions must come from the students.

It was important to find out what students thought about the activities in which they engaged as part of the project. Originally, I intended to survey all mathematics classes of participating teachers and interview a representative sample of students. However, this aspect of the study changed significantly for several reasons. First, only students from my classes and the HOD's classes participated in the project, fewer than I had anticipated. Second, and most important, I realised that it would be difficult to get frank information from pupils: they were likely to say what they thought I wanted to hear. The teachers, on examining my original questions, commented on this problem regarding the children's propensity to please. Also, I would not have been effective at interviewing the younger pupils. I could not interview them in Ndebele or Shona, and some would have difficulty expressing themselves in English. The HOD, EO, and I discussed the issue and we decided on a strategy which we thought would be more fruitful. The HOD and I held class discussions with his classes and my classes at the end of the second term. He did most of the talking and I took notes. Our purpose was two-fold: to identify their concerns and to show that we cared what they thought (Appendix F1). We followed the class discussions up with individual written feedback about specific activities we had done with them and about issues which had arisen during the course of the study, including the discussions. We prefaced the session with remarks about the intent of the exercise and discussed the questions, giving examples. The questions were open-ended (Appendix F2). The students were encouraged to write as much
or as little as they liked about any or all of the questions. In this way we hoped they would respond honestly and not just say what they felt was expected. Whereas in the class discussions only a few spoke out, in these sessions all students responded. Most wrote at length, although some were limited by their English. As well, I obtained biographical and personal information about my students at the beginning of term when I first met them.

None of the students' responses are edited for grammar or spelling. The students' own names are used, except when a student responded anonymously, in which case I provided a name for that student.

**Teachers.**

The situation for most teachers is routine, overload, and limits to reform (Fullan, 1991). This description certainly applies to teachers in Zimbabwe who normally teach five classes, each class in excess of forty students, and are required to spend a great deal of time preparing and marking. Many classes do not have enough textbooks. Sometimes they have to teach subjects for which they are not trained. (Jaji, 1990, Nyagura & Reece, 1990). "Innovation can be a two-edged sword. It can either aggravate the teachers' problems or provide a glimmer of hope. It can worsen the conditions of teaching, however unintentionally, or it can provide the support, stimulation and pressure to improve" (Fullan, 1991, p. 126). The key to effective change is to make the benefits at least equal the costs for teachers. The main benefit, to be balanced against personal costs in time, energy, and threat to sense of adequacy, is the sense of adequacy which comes from working with other teachers at the school and classroom level to improve practice.

Fullan (1991) maintains that nothing has promised so much or been so frustratingly wasteful as the thousands of workshops and conferences that have led to no significant change in practice when teachers return to their classrooms. The model of teacher development that I envisioned for the project was what Fullan calls "interactive professionalism"—teachers working in small groups, interacting frequently in the course of planning, testing new ideas, attempting to solve different problems, and assessing effectiveness, all with a view to getting better results with students.

Maravanyika (1990) asserts that indiscriminately selected and poorly motivated teachers are not good agents for reform because they lack the self-
confidence needed to apply innovative techniques or materials. Teachers are more likely to experiment after 7-10 years of teaching experience (Fullan, 1991). So teachers participating in reform should be trained, experienced, and motivated to change their practice.

I wanted the results of the study to have relevance to mainstream education in Zimbabwe. The purpose of the study was to make things better for the average student, not the academically or financially privileged. It was important, then, to select a school which was typical of the majority of schools in Zimbabwe, and teachers who were trained and experienced, but still typical. Jaji (1990) found that the majority of teachers in rural day schools are under 24 years of age and have no university education, or professional training. Most trained teachers in Zimbabwe are graduates of the teachers' colleges; they were the choice of teacher for this study. These teachers are most likely to be found in schools in high density areas of major towns and the two cities. The former group A schools in the towns and the mission schools in the rural areas would not be typical because they tend to have greater resources and have more university graduates on staff. The mission schools also usually have a selected intake of pupils. Selecting a rural school, other than a mission school, would be inappropriate as lack of resources and poorly trained, inexperienced teachers would prejudice the project to failure. The design of the study, then, called for a government school in a high density area and teachers who were graduates of teachers' colleges.

Understanding the subjective world of others is a necessary precondition for engaging in any change effort with them (Fullan, 1991). I interviewed the teachers at the beginning of the study (Appendix G1) to determine their education and career history (including professional development opportunities); what they felt the community, school, and Ministry expected of them; the constraints they experienced which prevented them from doing a better job; and the extent to which they used the methods suggested in the syllabus. I became more knowledgeable about the school; they became more knowledgeable about the project. Most important, I learned more about their teaching and their thoughts about teaching and learning.

**Activities and Data Collection During the Field Part of the Project**

The teacher interviews were conducted during spare periods or after school. Most were one-half to three-quarters of an hour in length. The
interviews were prefaced with remarks about the purpose and nature of the study and about confidentiality. They were semi-structured; I had specific questions but the teachers talked at length on any aspect of the interview which interested them. The interviews were recorded on audiotape. As soon as possible, either that evening or the following weekend, I listened to the tape and summarised the interview in my field notes as well as making notes about the conduct of the interview. The tapes were given to the teachers and they were encouraged to qualify or revise anything they had said. None of the teachers expressed any reservations about being recorded, nor any desire to make changes. The interviews were transcribed at the end of the project by a Zimbabwean friend. Surnames are used to refer to the teachers, as well as the headmaster and education officer, because this is common practice in Zimbabwe. In the initial interviews I assured each teacher that the information s/he provided would be confidential, hence the names have been changed in the thesis.

Towards the end of the project, in January and February of 1994, I interviewed the five teachers again (Appendix G2). This time the questions focused on issues which had arisen during the participation observation phase of the project. These were: the use of teaching aids, group work, marking, the mathematics club, a core syllabus, language, and communication. The final interviews also explored, in more detail than the initial interviews had, what the teachers thought about the methodology statements. Some of the interviews were done before the workshop we held in February, 1994 and some after; those that were done later asked for comment about the workshop.

I started teaching mid-May 1993 (the second term) and did the first interviews with the teachers in May and June. While everything was still new to me, I took photographs of the school. Throughout the study, I photographed the children doing activities in class and during mathematics club. The only difficulty was that the children wanted "cards," posed photographs of themselves to share with friends and relatives; it was sometimes difficult to explain that I needed the film for the project and wanted pictures of them "doing mathematics." It was a great disappointment that photographs of the workshop did not turn out.

My field notes included conversations with teachers and friends, incidents in class, staff and department meetings, workshops, and reflections.
on all of these. I wrote Africa Reports from my field notes. These were long letters to my supervisors back in Canada. At the end of the two teaching terms I gave Africa Reports to the head of department, headmaster, and education officer. The headmaster and EO provided written feedback and discussed the reports with me. The HOD and I talked about them more informally. I collected documents such as Ministry circulars, copies of syllabuses and examinations, newspaper articles, and magazines. I photocopied samples of students' work and filed these with my lesson plans for particular activities. The HOD wrote up some of the lessons he taught using the teaching aids and/or an activity-based approach. Student feedback was obtained just before their final examinations. In the December break I photocopied the teachers' schemes of work and minutes of staff and departmental meetings. Photocopying meant waiting in line and paying 35 cents per page to a business downtown. The headmaster gave me permission to take the documents out of the school. Using schemes, lesson plans, and student work, I prepared a rough curriculum package of lessons we had taught which exemplified the syllabus teaching methodology and left a copy at the teachers' college and at the school. I obtained English, science, and mathematics examination results for the school in 1992 and 1993.

During mid-year examinations, I visited the Department of Curriculum Studies at the University of Zimbabwe and spoke to lecturers there about my project and about the work they were doing with primary school teachers on a problem-solving approach to teaching science and mathematics. Another WUSC associate was involved in this project and, at her invitation, I returned to the University of Zimbabwe in the term break to participate in a workshop with these primary teachers. I continued to Malawi to visit a friend who was involved with a teacher education project at the University of Malawi, sponsored by the Free University of Amsterdam. I collected documents about these projects and commented on conversations with participants in my field notes.

In January and February of 1994, I "hung out" at the school. I gave extra lessons at noon hour to my previous Form Three class, now 4D. I observed lessons and prowled about the school grounds, talking to teachers and student teachers. When I observed a lesson, I wrote a descriptive summary of the lesson and gave it to the teacher for comment, asking in particular if the written summary was an accurate account of what had transpired. Again, no
one asked to make any changes. I did not always go to school; some days, I worked at the teachers' college or met with the EO at the regional office to plan our workshop or ran errands related to the workshop. The workshop was held the first week of February. The EO and I met several times afterwards and we prepared a summary report which I delivered to WUSC and to the Chief Education Officer: Standards Control at the Ministry (whom I had spoken to on my arrival) just before I left the country. I kept up a correspondence with the HOD. Also, the headmaster and EO each wrote me a letter informing me about developments since my departure.

Figure 2 summarises my activities from completion of the course work for my degree (May 1991) to completion of the thesis (June 1997). It may be helpful to refer to this table while reading subsequent chapters.
**Figure 2: Data Collection Timeline**

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 1991-April 1993</td>
<td>Project proposal to SFU, Ministry of Education, Zimbabwe Research Council, and WUSC.</td>
</tr>
<tr>
<td></td>
<td>Complete course work for master’s degree in mathematics education at SFU.</td>
</tr>
<tr>
<td></td>
<td>Collect resource materials.</td>
</tr>
<tr>
<td>May 1993</td>
<td>Arrival in Zimbabwe: meeting with WUSC and with Chief Education Officer: Standards Control in Harare to obtain letter of support.</td>
</tr>
<tr>
<td></td>
<td>Arrival in Gweru: meeting with Education Officer (Mathematics).</td>
</tr>
<tr>
<td></td>
<td>Introduction to school and settle in.</td>
</tr>
<tr>
<td></td>
<td>Start teaching Forms 1E, 2C, 3D, and 4B (beginning of the second term).</td>
</tr>
<tr>
<td></td>
<td>Interviews with Phiri (14/05), Mtisi (26/05), and Mabasa (31/05).</td>
</tr>
<tr>
<td></td>
<td><strong>Africa Report #1 (20/05).</strong></td>
</tr>
<tr>
<td>June 1993</td>
<td>Phiri and I attend the remedial teaching workshop.</td>
</tr>
<tr>
<td></td>
<td>Interview with Mugedeza (09/06).</td>
</tr>
<tr>
<td></td>
<td><strong>Africa Report #2 (24/06).</strong></td>
</tr>
<tr>
<td>July 1993</td>
<td>Mid-year examinations (mock ZJC and O-level): no classes for two weeks.</td>
</tr>
<tr>
<td></td>
<td>Visit to Department of Curriculum Studies at the University of Zimbabwe to talk with lecturers there.</td>
</tr>
<tr>
<td></td>
<td>Start giving extra lessons to some students in my own classes.</td>
</tr>
<tr>
<td>Month</td>
<td>Activities</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| August 1993 | Class discussions with 2A, 3B, 3D, 4B.  
|           | Term break.  
|           | Visit to teacher in-service projects at University of Zimbabwe and University of Malawi.  
|           | *Africa Reports #3 (11/08).*  
|           | *Africa Reports #4 (29/08).* |
| September 1993 | Continue teaching (third term).  
|           | Class discussions with 1E, 2C, 2D, 3E.  
|           | Phiri and I start a mathematics club (clubs term).  
|           | Consultation day with parents (16/09). |
| October 1993 | Start Friday afternoon lessons with Form Threes.  
|           | Start remedial lessons with Form Ones.  
|           | Interview Mambowa (18/10). |
| November 1993 | Individual student feedback.  
|           | ZJC and O-level examinations.  
|           | *Africa Report #5 (19/11).*  
|           | *Africa Report #6 (28/11).*  
|           | Mr. Phiri and Mr. Mukoyi respond to *Africa Reports.*  
| December 1993 | Term break.  
|           | Preliminary data analysis: summaries of student feedback and transcription of some of the teacher interviews.  
|           | Prepare curriculum package of lesson plans for school and GTC.  
|           | Document collection: school documents and teachers marks and schemes of work.  
|           | *Africa Report #7.*
January 1994
Lesson observations, including student teachers.
Preparation for workshop.
Interview Phiri (25/01).
Give extra lessons to some of my classes from the previous year.
Visit lecturer at Curriculum Development Unit in Harare.

February 1994
Interview Mabasa (01/02).
Cluster workshop for five secondary and two feeder primary schools (03-04/02).
Interview Mtisi (09/02) and Mugedeza (11/02).
Follow-up meeting with HODs (18/02).
Start report on workshop.

March 1994
Complete report on workshop (meetings with Mr. Shiri).
Presentation ceremony and distribution of resources to cluster schools.
Interview Mambowa (14/03).
Return to Canada.

March 1994-June 1997
Data analysis and writing of thesis.
Mr. Shiri’s response to Africa Reports (05/94).
Letter of appreciation from Mr. Mukoyi (10/94).
Continued correspondence with Mr. Phiri.

My Role as It Evolved

My role changed from almost complete participation at the beginning of the study to almost complete observation at the end. For several reasons, interaction with the teachers was different than the research proposal anticipated. The teachers had not volunteered as planned. It became apparent in the initial interviews that, given the pressure they felt to cover the
syllabus, they were not willing to experiment with their teaching. Their reaction to my resource package was lukewarm at best. The lesson observations did not happen. As a result, interaction over our teaching was limited. I became absorbed in my own teaching, using the resources I had brought.

Language was a factor which influenced my interaction with other teachers. I shared a desk in the staff room. Three of the other five mathematics teachers also worked in the staff room. Most of the conversation in the staffroom was in Shona and it was too lively and too fast for me to understand. Sometimes, if I got the gist, I could contribute in English. Much of the time I felt self-conscious; although they were always polite, I was not sure what the other teachers thought about my presence in the school. If I had spoken Shona, I think it would have been easier to participate in staff room conversation and establish rapport.

However, the HOD and I talked a lot. We often chatted outside the staff room at break and usually travelled to town together at the end of the day. We would walk to the main road, catch an emergency taxi or bus to town and then go our separate ways. I also had a special relationship with the senior mistress. I was staying with her relative, a former colleague and personal friend from the teachers' college. We lived a few blocks apart and the two households visited back and forth a lot. The senior mistress and I travelled to work together. We walked into town, which took us about one-half hour, and then got a lift with another teacher, an emergency taxi, or a bus. I also had many conversations about education with my friend and house-mate. Periodically, I stopped by the regional office and chatted with the EO. It was during one of these conversations that we first decided to organise the cluster workshop. When I was in Harare, I usually visited with my former colleague in the CTF/ZIMTA courses, now mathematics education officer in Harare. These were my special "informants," with whom I could broach nearly any subject; I gained considerable insight from our many conversations.

I found myself giving extra lessons to students. I met a small group of students from my own Form Four class at noon twice a week, and, as mid-year and final examinations approached, after school. The second term we agreed, as a department, to give extra lessons and I met with Form Threes from all classes on Friday afternoons. In 1994, I met at noon with a group of students from my Form Three class of 1993. The focus of this work with my
own classes was not tutorial, remedial help, or revision but to “cover” the topics we had not done in class because I had spent more time than the other teachers developing each topic. The students who attended these lessons were the ones who were most likely to pass the O-level examination. The term that I did not have responsibility for classes, when I was more an observer than a participant, I found that I looked forward to these lessons. I preferred the participant to the observer role.

In January of 1994, four mathematics student teachers arrived at the school for their practicum. The college had not been able to find places for all student teachers as headmasters were less keen to have them now that the practicum was only a term instead of a year. The local schools were required to take the extra student teachers. They lived in residence and commuted to school in the college bus. I had not expected to work with student teachers but they asked that I observe their lessons. They all attended the workshop. Several used the teaching aids that were in the school for a teaching project they were required to do as part of their practicum.

My role in the planning and execution of the workshop was different from my role(s) as a participant-observer in the school. I was now part of the school; I understood and shared the problems. I had serious doubts about my own effectiveness in the situation; I knew I did not have answers to complex problems. The workshop was truly a collaborative effort. The EO and the heads of departments planned and organised it. The school was very supportive, particularly the home economics department. My part was primarily that of a “go-fer.” The EO and I prepared a proposal for our workshop which I took to WUSC in Harare for funding approval. I also purchased class sets of compasses and protractors and organised the making of graph boards for each of the cluster schools. On the days of the workshop I presented one session. During the other sessions, I took detailed notes. With the HOD’s help, I organised a display of teaching aids from the school and GTC, along with samples of student work from lessons in which the aids had been used during the project. It was satisfying to work with others towards a common goal. We all enjoyed the collaboration and sense of purpose.
Data Analysis, Interpretation, and the Writing Process

In the field, I read and reread Fullan on educational change and Hammersley and Atkinson on ethnographic method, marking passages which reflected what I felt was happening to me. *Africa Reports* were my first stage of analysis. I also checked out ideas and perceptions in conversation with friends and colleagues.

On returning to Canada, I read the transcripts and listened to the tapes of the teacher interviews. I also read *Africa Reports*, student comments, my field notes, minutes of the meetings, newspaper articles, and magazines, immersing myself in the data while searching for meaningful ways to organise it. The categories which emerged were: teaching resources, group-work, mathematics club, marking, language, and communication. These corresponded with the focus of the final teacher interviews and student feedback questions. I circled sections of the interview transcripts, field notes, and student comments using these categories and copied these excerpts onto computer disk. The excerpts served as starting points for writing Chapters 4 (context), 6 (students), and 7 (teachers). Most of Chapter 5 (my teaching experience) is taken directly from *Africa Reports*. Chapter 8, about in-service and professional development, is based partly on my field notes and documents from other in-service projects and partly on further analysis of the workshop report the education officer and I prepared for the Ministry.

Writing was a much more difficult process than I had imagined. I started teaching again, which delayed the writing process. In addition to the practical difficulty of time, I was ready to move on in my professional life. I identified with what I had read about the difficulties of getting teachers to write up their own research; we are more interested in applying what we have learned than documenting it for others.

The fact that the coursework for my master's program was embedded in one society and my thesis work and recent teaching experience in another proved to be a source of considerable dissonance to me throughout the program and research, as well as the writing process. I knew more about mathematics curriculum and instruction when I returned to Zimbabwe in 1993, but I was further removed from the context, and more influenced by a different (North American) educational paradigm. I experienced angst over the literature review. I often felt that the American literature about mathematics education was taking me on a detour. It seemed I was doing
exactly what I meant to criticise. I had spent two years at Simon Fraser in a program which stressed that developments in school mathematics curriculum and in pedagogy, are related to historical, cultural, and psychological forces operating within society; yet I was reading the literature of a country which had had little influence on the Zimbabwean educational system. Any historical educational connections to another country were to Britain or to South Africa. Nor had I studied or taught in the United States. While writing, many conversations at SFU immobilised me. I became self-conscious about the thesis; as an “outsider” I felt I had nothing of importance to say. I continued to write by focusing on the data, my “insider” role, and my desire to make personal sense of it all. I was supported in this by my thesis advisors and my international friends who encouraged me to write whatever I had to say.

The question of audience kept coming up in discussions about my writing. People at SFU sometimes asked me to explain things in the thesis which I knew would be obvious to Zimbabweans. I did not want to write for an SFU audience. I wanted what I said to be most meaningful to those who sponsored and participated in the research but, given the delay in producing the thesis, I had growing doubts about whether it would be of any interest or have any impact in Zimbabwe. The longer it took to write the thesis, the further removed I was from what had happened. While this may have helped in the analytic process, I felt less grounded. Eventually I accepted that, as a graduate student, I had to write for both audiences. I sincerely hope any insights the thesis provides about mathematics curriculum and instruction will be most useful to Zimbabwean educators and decision-makers.
"... a former group B school in a high density suburb. It had been the F1 or academic school" (p.64)

"... our staff room. It's so crowded" (p.69)
Form 1E classroom
“Form One children sat at two rows of large tables and a double row of desks down the middle of the room between the tables” (p.65)

Form 4B classroom
“the Form Fours sat at individual desks in classrooms which were larger and newer” (p.65)
Chapter Four
Kwelo Secondary School, Zimbabwe 1993

This chapter describes the social, political, and educational environment I returned to in 1993. The description is based on documents collected during the study, in particular Berridge (1993). It also includes a brief history of the school and a description of the school as it was in 1993. In the initial interviews, the teachers talked about their educational background and provided information about the mathematics department and the children. The education officer (EO) had visited the school in March and prepared a report for the Ministry. The chapter draws on this report and comments students made about themselves to triangulate with what the teachers said about the school and the nature of the students. Without understanding the context of education in post-independence Zimbabwe, it is difficult to appreciate issues which arise later in the thesis.


When I returned to Zimbabwe in 1993 life was more difficult than when I left in 1990. An Economic Structural Adjustment Program (ESAP) had been introduced in 1990, resulting in loss of jobs and increased prices. Theft had increased and street children were common, not just in Harare, but in our small town as well. Many people were eking out a living selling vegetables on the street. The country was just recovering from a severe drought experienced in 1991 and 1992 and the effects of the drought exacerbated the financial hardship of ESAP.

The educational system was affected by the economic situation. Many young people with O-levels and A-levels were unable to obtain employment or to continue with their education. The Education Act had been amended in 1992 to allow the introduction of fees at primary level in the urban areas. Primary education in the rural areas was still free. School and examination fees at secondary level had been increased. As a result, many urban parents were sending their children to stay with relatives and go to schools in the rural areas. When I arrived the Regional Office was in the process of relocating teachers to rural areas from urban schools which were overstaffed. I was told that some students at our school who had not been able to pay their examination fees the previous year were back this year in Form Four. This was the case for other schools as well; for financial reasons, many students
were taking several years to write the examinations to obtain the minimum five O-level subjects. At our school, many of the students' fees were paid by the Social Dimension Fund which had been introduced to cushion the social effects of ESAP.

From 1980 until now the focus of education had been expansion—more primary and secondary schools, more technical schools, more teachers' colleges, and more university places. As well, innovative teacher education programs had been introduced to train more teachers. The year 1993 was a time for consolidation with growing recognition of the need to change the emphasis from "quantity" to "quality." Concern about the declining pass rate at O-level (which ranged from 50%-60% at private and church schools to 14% at district council schools) was being expressed by all sectors of the community. The examination results, coupled with the fact that over 250 000 young people were leaving school each year with no chance of finding a job (previously five O-levels had virtually guaranteed a "white-collar" job), were raising questions about the appropriateness of present curricula to prepare students for life after school.

Description of the School

The following description of the school is based on the school magazine of 1984, minutes of staff and department meetings, and my own observations. Kwelo Secondary School had opened in 1963 with 100 pupils and had an enrolment of 600 at independence. By 1984 that had increased to 1 532 as people took advantage of increased educational opportunity; by 1993 it was down to 932. The school was a former group B school in a high density suburb. It had been the F1 or academic school; nearby was the F2 school with more facilities for practical subjects. Kwelo now offered both academic subjects (English, Shona, mathematics, science, history, geography) and practical subjects (commerce, accounting, book-keeping, foods and nutrition, fashion and fabrics, metalwork, brickwork, and technical drawing). We had a foods and nutrition laboratory, two science laboratories, and workshops for metalwork and brickwork. There was a library with round tables and bookshelves around the perimeter, and a "Great Hall" where the students and staff assembled Monday and Friday mornings. The children stood and the staff sat on chairs on the stage. There was a large playing field and a
swimming pool. The swimming pool, though, had not been functional since the drought; broken desks were stored in the swimming pool area.

The Form One and Form Two classrooms were crowded, particularly the former. Form One children sat at two rows of large tables and at a double row of desks down the middle of the room between the tables. The Form Threes used the laboratory and practical areas as home rooms and "roved" for their lessons to the Form One or Form Two classrooms which were vacated by children going to science or practical lessons. The Form Fours sat at individual desks in classrooms which were larger and newer. The electricity supply to the classrooms had been turned off as many of the wires in the outlets and light sockets were bare; the light bulbs and socket covers had been taken. Most of the windows in the older classrooms were broken.

Through the parent-teacher association, the community had raised money to build two more classrooms since 1980. In 1993, though, many parents were finding it difficult, after paying school fees and buying uniforms, to come up with an extra $30 deposit which the school required to cover possible damages or losses. The school normally provided exercise books for the children. When the supply sometimes ran out, not all parents could afford to buy exercise books and some children came to school without. Despite financial hardship, the previous year parents had supported the prize-giving ceremony and had helped to buy paper for the school magazine and examinations. Due to the paper shortage Form Ones had written end-of-term examinations in their exercise books. Tests, except for English and Shona comprehension, had been written on the board. Although the community was very supportive of the school, it was hard to help in the difficult economic times.

From 1979 to 1984 all the students in 4A and 4B had qualified for A-level. However, in 1990 17% of the students writing O-level passed five subjects; in 1991 11% had passed. In 1992 the pass rate was 13%. The school was under considerable pressure from the regional office to improve the examination results in 1993.
The Mathematics Teachers

Four of the five mathematics teachers at the school had attended secondary teachers’ colleges. Two had graduated from Hillside Teachers’ College in Bulawayo (Mr. Phiri, Mrs. Mabasa), one had gone to Gweru (Mr. Mtisi) and one to Belvedere in Harare (Mrs. Mugedeza). Mr. Mambowa was trained as a primary teacher and had earned a BEd degree in geography from the University of Zimbabwe in 1986. Mtisi had done his training before independence (1974) and had been at Kwelo since 1977. He was senior master and worked out of his own office at the school. The other teachers had trained since independence and had come to the school more recently, all since 1988. Mugedeza had worked as a computer operator and Phiri had done temporary teaching in his home area, Mberengwa, before entering college.

Phiri had majored in history and mathematics; Mugedeza in home economics and mathematics (at Belvedere students are required to do one technical subject). At the time of the study both were teaching only mathematics, although the last term I was there Mugedeza had some home economics classes as well. She would have preferred to do mathematics only. Phiri enjoyed teaching both mathematics and history; he did not have any history classes at the time because he was head of the mathematics department. Mambowa was not comfortable about teaching mathematics. Whereas the other teachers usually had classes from two forms, he taught three Form One classes.

The Mathematics Department

This description of the department is based on information from the teachers and from a report on the department obtained from the school files. The report was written by the EO and directed to the Regional Director, Midlands. Quotes in the following paragraph are from this report.

The education officer had visited the department on 24 March 1993 “to discuss the effectiveness of the department in curriculum implementation and innovation with a view to giving advice where necessary.” In his report he commented that storage (shelves in a work-space behind a classroom and two built-in cupboards in separate classrooms) was not convenient. The shortage of textbooks was due to the fact that pupils were “reluctant to return books at the end of the year.” The average class size (ranging from 38 to 45) was “within acceptable limits.” He examined schemes of work, records of
marks, and a sample of exercise books for each member of the department, as well as departmental documents, and concluded that the department was making "commendable effort in implementing the mathematics curriculum, ... largely attributable to effective leadership and a culture of teamwork that has been cultivated in the department." The "professional paperwork was up to date and written work adequate and regularly supervised" and the lessons he observed were "successful." However, he commented that teachers "neglected teaching/learning aids." "The column on methods, activities and aids could do with more detail and variety ... so as to make it clear how the work, so planned, would be covered." The O-level results (1990—15.9%, 1991—13.5%, 1992—9.3%) were "gloomy" and called for "urgent action by the department."

The teachers all commented about teaching resources when I asked them in the initial interviews to describe the difficulties they experienced in teaching mathematics. The school had a Banda duplicator (spirit master) but it was not working. There had not been any manila sheets to make charts for the previous three years (there were now). The department had just acquired some sets of chalkboard instruments (ruler, protractor, compass, and set square) which it had been requested for some time. Sometimes even chalk was in short supply.

What I mean is, like this other time, you were supposed to go and teach, and then you didn’t have any chalks, you see. How are you expected to teach when, to write, when you have a piece, just a small piece of chalk? It’s rather difficult. Some of the boards are very old. You can’t expect kids to see what you write at the boards when the boards are as terrible as all that ... No matter how you try to, no matter how good your writing is, no matter how neat you are, then they won’t be able to read what you write. (Mugedeza, interview #1)

The department often did not have even the basic resources for teaching.

Although the school provided the children with exercise books and textbooks, they had to buy their own graph exercise books and mathematical instruments. The fact that many students did not have these supplies was a problem for the teachers.

The situation is better in good classes than it is in less able classes such that, well, you can collect enough [mathematics
instruments] in the end. You can even ask them to go borrow from their friends and the like. At least you can do something. (Phiri, interview #1)

... mathematical instruments. Our kids cannot afford. ... Some of them cannot use these instruments because they have never had them. They can't operate a protractor. They can't use a pair of compasses because they begin Form One without those. ... If you just show them and they don't use them it doesn't help at all. ... You end up teaching them how to measure angles even in Form Four. ... And graph books ... I don't think they have graph books from Form One. They just sit there. They can't afford to buy graph books. We always send them home. They come back without. (Mabasa, interview #1)

One of the major difficulties teachers experienced, then, was that the children's parents could not afford to buy school supplies.

In the lower forms it was routine to share textbooks, one to two or three children, which created problems for both students and teachers.

Shortage of textbooks. The kids have to share. And really if you are sharing it is quite difficult. One goes with the book today and what are you going to use? ... Sometimes they will come and say "I don't have a book, so how do you expect me to do the work when I didn't have the book which had the homework to do?" But really we show them that you have to do the work. "When you are at school make sure that you grab a book before you go and write down those questions." But still, if a kid doesn't remember how to work that problem, if he didn't write anything down when you were teaching, then they won't know if they don't have a textbook. (Mugedeza, interview #1)

Even though the class sizes were "within acceptable limits," the large numbers of pupils in each class made teaching difficult.

The classes are very big and it's difficult to attend in that forty minutes to each and every person if you have to help them individually. Right, so 40 minutes you can get 40 students taking one minute then the rest won't have. So it means you won't be teaching you see. So it's very difficult to attend to each and every person. You won't know the weaknesses of each pupil. If there were 20, 30, that's reasonable. Not 46, 45. (Mugedeza, interview #1)

The staff room was crowded as well.
And I also feel that as a teacher you need enough space to breathe. Like, look at our staff room. It’s so crowded. And then there are your books, you have to put them, some down. You need to be organised for everything to run smooth. So I think, having somewhere where you can work, I mean, it’s good to work in a good environment. (Mugedeza, interview #1)

These were some of the difficulties then: crowded working conditions, large class sizes, and a shortage of such basic resources as textbooks, mathematical instruments, exercise books, and graph books.

The Mathematics Students

In the initial interviews the teachers volunteered information about the students they taught. Most of their comments came in response to a question I asked about what influenced their teaching.

From these initial conversations with the teachers I formed an image of two types of students in the school. The majority had a weak background in mathematics and either struggled or did not attempt the subject at all.

Like I always tell them, I am on leave in this school because you find pupils do not come to you to ask you problems. If they do, it’s once in a blue moon, as if to say they know everything. Yet they don’t. ... You give them the homework. They do not even do it. If they do it, it’s just to please you that they’ve done the homework. I don’t know. You’re joining us ... You’ll find out. (Phiri, interview #1)

This year for example I am teaching 2E. It’s the worst class in Form Two. ... To start with ... you dread going in there because pupils will just be staring at you. ... because of the training you would perhaps try to simplify your material to their level of understanding, hopefully. But still, I have met with little success. (Mtisi, interview #1)

Students who tried, even though they found it difficult, were pleased when they experienced success.

In the previous year I had a Form Four C and they were working very well. But they were a weak group, weaker than the previous one. But on the whole I tried to help them. They worked very hard and in the end they did very well. We had very few, maybe two or three As. And a few Bs. But the majority
passed. Well I should admit they were a weak class. But they were willing to work. That's what helped them quite a lot. (Phiri, interview #1)

Some say it's difficult, but they still like it. You will see they try very hard. These are very interesting to teach because you know this one likes the subject even if he is finding it difficult. But you find you can explain slowly. Then you end up when he succeeds, you find that he is very happy. (Mabasa, interview #2)

... some of the kids really, they like mathematics. They just like it though they are not really good at it. They like it. And it's quite interesting when you see that the kids at least make it, some of them make an effort. They try. They do try. They do try. (Mugedeza, interview #1)

It's surprising they don't look that discouraged. They keep trying. They keep trying. ... They are interested. The problem is that they don't have the correct background. They like it. But they don't have the background. And worse still, we are rushing things ... (Mambowa, interview #1)

Although many students were having difficulty they wanted to succeed. But they did not have a good foundation and teachers did not always take time to start where they were and explain slowly. When the teachers did adapt their instruction to the students they were still not always successful with the lower classes.

It seemed to me that the teachers had considerable empathy with these lower-achieving students.

Well, most of our kids here are very slow. ... But since there is this worry about covering the syllabus we end up rushing these kids when they are slow. So I think they end up getting confused. ... you have a mixture and most of them are very slow. So you have to change the methods. ... when you are teaching these kids here, when you tell them about a cylinder you can't just describe it and leave it there. You have to show them the cylinder and you have to make those paper ones so that they can cut so that they see that this is, it turns into a rectangle. [To fast kids] you could just explain that if you cut this it turns into a rectangle. So I think the slow kids need more practical. (Mabasa, interview #1)
... with the kind of classes that we have you have to take them stage by stage. They are not very bright and really, they haven't got that drive you see. They want somebody to drive them. They can't do their work alone. (Mugedeza, interview #1)

At the same time, the lack of success of these students at ZJC and O-level was discouraging for the teachers as they were being held accountable, in some measure, for the students' failure.

The teachers' major satisfaction came from the students in the A and B classes who could keep up with the pace of instruction and would come for extra help.

Last year there was a very bright pupil here. Tendai is now doing lower sixth. She was quite good. She would come and ask. She did well. (Phiri, interview #1)

There was a time when I had a group, a very good group when I was teaching 4A. It was about 1986. It was quite a good group. You would be teaching pupils who were enthusiastic, who would bother you time and again. You would enjoy it actually. You would be on your toes all the time. (Mtisi, interview #1)

The teachers liked it when students asked them questions. These were students who were likely to continue on to A-level.

There were mixed perceptions as to the attitude and achievement of girls versus boys. Two of the teachers felt that boys do better because they work harder; girls have less confidence, and girls lose interest about Form Two. One of the women commented that the children at the school were not lacking in female role models. To me, gender did not seem to be a particularly big issue compared to other concerns expressed by the teachers.

The teachers' views of the students corresponded with what students in my classes said when I first met them. I asked them to write about themselves and how they viewed mathematics on our first meeting. Although many did not say that they did not understand the subject, they still liked it.

I think mathematics is a good subject. I am interested in mathematics but I don't even understand. I sometimes pass by the grace of God. ... This year I have learned a lot but I understand a few about it. (Appolonia, 1A)
I think I will fail at ZJC because I am not good at Mathematics, although I like the subject. I think for me to learn well I need assistance when I am at home; I don't have someone to explain to me some problems which I don't understand in a 40 minute lesson. (Joyce, 2A)

I like learning mathematics although sometimes I don’t understand but I like asking questions where I cannot understand so that I can keep on trying. ... I sometimes hate maths because I cannot understand about equations and some other topics but I hope I will be excellent because I will keep on paying attention. (Sitshengisiwe, 2C)

I don’t think I will pass because I am very dull in Maths. I like the subject, try my best, but fail. (Memory, 4B)

I love maths most and I prefer to pass it on the ZJC. Maths is not a very difficult subject but our heads are the ones which are difficult. There is only one chapter in maths which is very difficult that is the chapter of sets. A person who invented the sets was trying to make it difficult for us. (Sam, 2C)

It was typical of the children to blame themselves for their lack of success (and attribute success to God). Their heads were difficult, not the subject. Other students were more confident.

I predict that I am going to pass with flying colours. The reason is that I checked my performance and I saw that it is up to the required standard. Do or die I’m going to pass. (Tendai, 2A)

Of course I do face difficulties at times because of lack of revision but now I think I do not face much difficulties as I used to due to the fact that I seek advice and learn more that way. Because of revision and tackling past exam paper’s problems I think I do have the potential to attribute success through hard working and a bit of luck. (Chamunorwa, 4B)

These were the students whom the teachers found enjoyable to teach. They attributed their success to their own hard work and initiative.

Students and teachers used the same labels. The majority of students were “weak,” “slow,” and “not very bright” or “dull.” The higher-achieving students were “good,” “fast,” and “bright.”

From the initial interviews with the teachers in May I had a good idea of what I would be facing in my classes. Despite remarkable achievements in education, schools like Kwelo were confronting some of the negative
consequences of the rapid education expansion of the preceding decade. The teachers were competent, congenial, and cooperative, but I sensed that my project was not going to evolve quite as I had anticipated. Given the present context of education in our school, experimenting with teaching methods was not going to be a high priority for the teachers.
Form 1Es using calculators to write decimal equivalents of fractions
"the pupils work well in groups" (p. 77)

students at the mathematics club
"Eighteen students came and we played the isometry game" (p. 75)
Chapter Five
My Teaching Experience

This chapter is a personal account of the first two terms in the school, from May 1993 to December 1993. It has been prepared by taking excerpts from Africa Reports which pertain to the key organisers: teaching methods (activities and teaching aids, group-work, mathematics club), assessment (marking routine), curriculum (core syllabus), and classroom discourse (noise, language). The fact that Africa Reports were written while I was teaching means that these comments reflect my activities, thoughts, and feelings at the time and are not influenced by subsequent learning and reflection. Africa Reports, as described in Chapter 3, were long letters written to my supervisors back in Canada. They were written from my field notes, which included summaries of conversations with teachers and friends, incidents in class, staff and department meetings, workshops, and reflections on all of these. Chapters 6 and 7 examine these issues in more depth by reporting on teacher and student perceptions of the same events, issues, and concerns.

Africa Report #1: 20 May 1993

One more day to finish my first week of teaching. Tomorrow all the mathematics classes write tests. I don’t have any preparation tonight as the tests my classes will write are being set by other teachers. Another Friday it will be my turn to set the test. The tests will be every second Friday. Alternate Fridays the classes will work on an exercise which is to be collected and marked thoroughly.

The week has gone relatively well. I interviewed Phiri last Friday afternoon. ... Yesterday we came with Mr. Mtisi and collected the teaching aids from where I am staying. So far I haven’t had much contact with the other teachers; I’ve just been doing my thing. ...

Wednesday after school is clubs day. We decided to start a mathematics club. Mr. Phiri went around to 4A and 4B. Eighteen students came and we played the isometry game (Appendix H). This was quite successful. They got into the game fairly quickly and seemed to enjoy playing it. We used the Miras to check reflections and tracing paper to check rotations and I am sure some students learned quite a bit. I was pleased; it seemed well worth the effort spent the last week before leaving, making and laminating a nice set of
the games. In fact, I thought the students responded just as I imagined they would. I think Mr. Phiri appreciated that the game fit the syllabus very well; he and I both went around and helped the students with their moves.

On the whole, I think the students will respond quite positively to activities in mathematics. The greater difficulty, I think, will be establishing the right kind of rapport with the teachers. I'm not quite sure how to handle this. Mr. Phiri looked at the resource file I brought; I think he had some reservations (activities are time-consuming) and we haven't distributed the other binders yet. I think I will just do my job and try to establish credibility for the first few weeks, other than getting the initial interviews done.

I really couldn't ask for better cooperation, so far. Already many of the problems to be faced are becoming apparent: the emphasis on examination preparation and "covering" the syllabus; the fact that, with streaming, the lower classes are seen as a lost cause; crowded classrooms in the lower forms making it difficult to move around the room. But there is a nice atmosphere in the school and the pupils are as willing as I remember them.

Africa Report #2: 24 June 1993

I have been teaching for over a month. I have found it hard to work on this report because I am so tired when I come home. I rest for a while, prepare lessons, have supper and go to bed by 9:30 to be up at 6:00.

Teachers are not aware of the methodology in the syllabus. It appears they prepare their schemes from the school syllabus. They don't see much difference in this syllabus and the Cambridge International Syllabus; just that some of the topics have been dropped, particularly at ZJC (Zimbabwe Junior Certificate). .... There is now a calculator alternative available in Zimbabwe, although our school is not doing it as most of the children could not afford calculators; I have seen a few with calculators, though.

Teachers see a need for an alternative curriculum for most of the pupils. They don't feel that they have a mandate to pursue a curriculum that would meet more of the needs of the children they teach, however. They feel a pressure to "cover" the O-level syllabus. Just how much this is perceived and how much it is real, I'm not sure. It's not as if the children are likely to do any worse on the examinations.

The pupils have responded very positively to the activities I have done in class. With the Form Twos (2C) and Threes (3D) I haven't experienced any
problems. The Form Fours (4B) do not all settle down to the task, although they seem to enjoy the activity. The Form Ones (1E) enjoy the activities but are far too rowdy. I will have to work at getting the class atmosphere I want here; I think it can be done; I will resist the temptation to back off altogether. There is a huge turn-out to our mathematics club on Wednesday afternoons. Last week we had to use two classrooms.

The pupils work well in groups. It just seems natural for them. They are extremely good about returning equipment. Nothing has gone missing (well, maybe some rubber bands in Form Four). Even without being asked to do so, one child will go around and collect whatever I have given out. The teachers all use some form of group work at times. I have picked up the idea of having a set of exercise books just for group activities; I was giving out pieces of paper or just collecting one exercise book from the group. I think there is a lot of scope here for addressing some of the difficulties. I am experimenting with assigning different tasks depending on the feedback I get from the marking.

A lot of time is spent marking. Teachers feel they must mark almost everything the children write. Our tables in the staff room are piled high with exercise books and there is a constant procession of students bringing piles of exercise books to the staff room. In mathematics, we are expected to give a written exercise, done individually, every second Friday. The other Friday is a test, prepared by any of the form teachers. All the forms then write the same test. I can barely keep up with the Friday marking, let alone mark every exercise. There is a lot of value to it, because I really know what they can and cannot do.

I have two major problems with the expectation though, and I'm not sure yet what to do about either. One, there is other marking I would like to do, in response to particular things we do in class, and it is hard to fit this in. I worry that we all just get caught up in the routine of marking and stop thinking about what we're really trying to accomplish. Two, I find I am allocating marks like 1/20, 2/20 ... with an occasional 8/20, 9/20. This only shows that these tests are inappropriate for these students. It is difficult to use the results for further teaching and learning. Which, to me, makes the whole exercise seem useless. We lost the class time which might have been spent learning. My marking time might have been spent in preparation or marking something else. I checked the marks the other classes were getting for the
Form Twos. 2A was doing fine; I have 2C; 2D and 2E were getting nearly all zeros. When it was my turn, I set quite a straightforward test and was happier with the results, but I am sure when I check I will find that the test was inappropriate for 2A. It seems such a contradiction to stream the children and then not adapt to them. My only thought so far is either to set separate tests for 2A and the rest or to set the first question anticipating most of the pupils will get it, and set one more difficult question which only 2A and a few others will attempt and not grade the other classes on this question.

The whole question of why they do so poorly needs to be investigated. Often, they seem to have mastered something in class and then cannot do it on the test. I think they have been "tested-out" in their academic career and just stop thinking as soon as they are expected to do something on their own. They copy from other students, as well. And they always write something, very neatly, even if they don't know anything at all. They give the appearance of being very busy putting down what they know during the test. Now, I watch some closely while they are writing. One day, in 3D, I watched a girl copy the diagram from the textbook for a trigonometry problem and carefully shade the lake for much of the period. This doesn't apply to the kids who have confidence and are doing okay, of course.

Africa Report #3: 11 August 1993

Almost two months have elapsed since I wrote the last report. ...

I am still on a measurement unit with the Form Ones. I did an activity on the area of a leaf (Appendix II) from the science text which I thought went quite well. We also determined the volume of a box which didn't go quite as well—they didn't know which dimension was the height and though they could tell me that volume = length * width * height, it wasn't that straightforward to apply it. We did an exercise on perimeter using the geoboards just before school closed. ... The Form Ones have settled down quite well; I think they were glad to have me back after my absence [I had been ill with the flu].

We're working on expansion of algebraic expressions in Form Two. I was pleased on the mid-year examination that they seemed to get the simplest equation, many intuitively, whereas many of the Form Threes (I marked all the Form Three papers) did not get a simple equation correct, I think because they were just trying to remember rules. I tried an activity with manila
rectangles and square (algebra tiles) to introduce expansion but wasn’t entirely happy with it. I made them when I was ill with the flu the first time and made fourteen sets but only got seven instruction cards done, so had to write the instructions on the board as well. We didn’t have enough time to follow up the activity before I was ill again. Then we had the mid-year exams. So I decided to repeat the activity after the exams but not all the children were there, they didn’t have the group exercise books in class and only about a dozen have their own exercise books. (Most teachers don’t work with the kids after exams because they are busy marking.) The Zimbabwe bird activity was quite successful (Appendix 12).

In 3D we measured heights to draw a frequency histogram. They did this very well, both gathering the data and drawing the histogram in groups and individually. I think they had already been exposed to the concepts in earlier work in mathematics and in science. My impression is that they did better than the other classes on the mid-year exam on that question [about histograms]. (As I set the paper, I deliberately made the questions correspond to some of our activities.) All the students found the statistics questions easier, though. Only 3A got anywhere with the trigonometry question so there is no evidence there that the activity helped. 3B, 3C, and 3D were the classes that did the flagpole activity (Appendix 13). ... I also prepared a lesson interpreting graphs from an atlas which they use in geography classes. Again, I was pleased with this activity. I wanted Phiri to use it too and he would have, but his class was on a different topic by the time I came back.

We finished a unit on vectors and matrices (Appendix 14) and have just started transformation geometry in Form Four. The other classes have done more transformation geometry and/or linear programming. Because of this, I assume, the other classes seemed to do better on paper 2 of the mid-year examination. I discussed this with a small group of the keener students after giving the papers back and received what I thought was positive feedback. Taurai said, after all, we were only one unit behind and they were happy because they understood. Chamunorwa said that the work with vectors on the geoboards helped him to get the concept of direction. I had a small group (3-6 students) who came for extra lessons during the mid-year examinations. We did a unit on linear programming and I think they have almost mastered it. So I don’t think they feel cheated. About half the class has basically given up at this stage and about one-quarter are working hard. I plan to take time
with transformation geometry in class, insisting that all participate and offer extra classes for review and for probability and statistics. There are only five teaching weeks next term. Apparently, 4B is perceived by many teachers as a difficult class. The students themselves complain about the class atmosphere. I find most do not settle down to an activity very well. I was annoyed that many did not bring their exercise books after the mid-years even though they knew I would be coming to class. I think the behaviour is mostly because they have given up. They laughed and made a lot of noise when I gave the exam back.

I talk to Phiri nearly every day. We usually walk to the bus stop together after school (15-20 minutes) and go into town together. We talk a lot about our experiences, the issues and concerns.

He tried the expansion lesson with 2A and 2D. He was quite keen about it. ... He would have tried the Form Three graph activity but his class was ahead of mine by the time I came back and he didn’t want to take the time.

We’ve also been working on making geoboards, but haven’t finished yet. The materials are all at his house. We’ve painted and he has completed three small ones, but we have yet to finish hammering nails into the big ones. I took the one I had borrowed back to GTC. We will work on them again next week sometime; we plan to have them finished before school opens again.

He also borrowed the book on cooperative learning. I’m waiting to see what he thinks. I think some of it doesn’t apply as the children are so co-operative anyway. So I’m very interested to see what he learns from it.

Phiri and I went one afternoon during examinations to talk to Mr. Shiri [the education officer]. I have gone a couple of times on my own. ... We had three issues to discuss: (1) the possibility of a core school syllabus, (2) how best to obtain information from pupils, and (3) the possibility of establishing a mathematics resource centre using WUSC’s small project fund. On the first (and most pressing matter) he indicated that other teachers are approaching him with the same concerns. We were given a go-ahead to adapt, but he stressed that whatever we do should be documented, and that it was very important to have a combined, consultative effort. At the time, I worried about that as I wasn’t sure that the other teachers would be in agreement with the proposal or, even if they were, that we would manage to come up with a core syllabus. We don’t meet regularly, despite the comment in Shiri’s report
on the department to that effect. Shiri talked about identifying major themes, commenting that taking the time on one topic could save time later on another area that requires that background. To me, this is the most important issue in education in Zimbabwe at this time. I doubt teaching methods will change much until teachers feel free to adapt to the children they teach.

We agreed that the best way to go with the pupils would be to have class discussions first. I still want to follow that up with a questionnaire and individual interviews, but I’m confused as to a suitable format for a questionnaire. The women tell me the children, especially my own classes, will tell me what I want to hear.

Shiri was keen on the idea of a resource centre, so the next step is to explore it further with WUSC. Then he will speak to the regional director. He thinks it will be possible to get space at the regional office. I want to explore with more mathematics educators here as to what they think should go into such a resource centre. Shiri’s and Phiri’s suggestions were mostly print materials. When I mentioned the idea to two friends of mine when we were out for a drink one night, they looked at each other, shrugged and said “More dependency.” So that has deflated me a bit about this idea. ...

We had a department meeting at the end of term. Most of the discussion centred on results—the number of people passing the mid-year examinations in each form. This is the picture: 1A-23, 1B-21, 1 (not available), 1D-1, 1E-1, 1F (not available); 2A-15, 2B-3, 2C-0, 2D-0, 2E-0; 3A-10, 3B-1, 3C-0, 3D-1, 3E-0; 4A-8, 4B-1, 4C-3, 4D-1, 4E-0, 4F-0. We also identified the number of children in the 40%—49% range and Phiri received support for the idea of having an accelerated class in each form made up of these children which would meet once a week. Phiri and Mtisi are going to prepare reports on the common errors in the examinations for the Form Twos and the Form Fours. I hope these comments give some indication of the pressure that the teachers are under to get “results.” Why so much concern when everyone knows that the O-level standard is too high for the majority of the pupils? Why aren’t we worrying more about the rest of the kids? ...

It’s not that we’re not worrying about them at all. We’re going ahead with the remedial programme dictated by the regional office of the Ministry. We’ve identified 13 children who are weak in mathematics but okay in English. Two are from my 1E class. The rest of 1E and 1F don’t qualify because they are weak in English and mathematics. So even this is aimed at
increasing passes, I guess. However, we’ve identified one block in the timetable when we can get together children from 1A, 1B, and 1C, and another block for 1D, 1E, and 1F. We will start to try to do something with the kids next term. Also, we agreed to start working on a core syllabus, given that we have the support of the regional office. The teachers were keen about this, especially Mtisi. ...

Africa Report #4: 29 August 1993

... Does the system really want the changes that the curriculum developers are suggesting? Who are the people writing the aims and methodology statements of the syllabus? Do these really represent the wishes and opinions of the Ministry and of society in general? It seems the teachers are getting a mixed message from the Ministry and that they are listening to the part which they hear the loudest. And that is that their major responsibility is to the children who have some chance of passing the examinations (primary, ZJc, O-level) and that the best way to fulfil this responsibility is to “cover” the syllabus with all the children. They realise something is not quite right about this but feel powerless to do anything about it. The other part of the message (the stated syllabus aims and suggested methodology) is very weak indeed, as teachers seem not to have read that part of the syllabus and there is little encouragement from the regional office of the Ministry to implement these suggestions, as far as I can see.

... She [Dr. Jaji] said that the idea [of an alternative syllabus] had been considered and rejected at independence in 1980. At that time the government wanted to fulfil parents’ expectations of an O-level education for their children; the important priority was to provide school places for all. The issue came up again in 1987/88 when the present Cambridge local syllabus was being drafted. By this time the Ministry supported the idea as it had become apparent that all the children were not going to pass O-level. They proposed something along the lines of the science syllabus, with a core and extended component. Apparently, when the examinations branch took this proposal to the Cambridge examiners it was rejected as the core component would not be of high enough standard to be sanctioned by Cambridge as an academic examining board. ... The Ministry still wanted to go ahead with the idea and it was brought before Parliament. It was rejected on the grounds that society would not be willing to accept anything less than O-level as being

82
meaningful. When I asked: "What next? The problem is still there. What do the Ministry and/or curriculum developers have in mind now?" there was no answer. They didn’t know.

I’m beginning to see that most Zimbabweans have different priorities than expatriates. Does this reflect a different level of commitment or simply a more realistic appraisal of the situation? Is there an expertise factor? Why was this in-service workshop being run primarily by expatriates? Why do I seem to be in my own space educationally at Kwelo? Is it a case of inappropriate Western ideas being imposed on Africa, as some of my friends are suggesting? I want to think some educational principles are universal. However, I think if the expatriate factor is a problem for some people, then it won’t be possible to get past that to the educational issues. If the educational principles are rational, does it matter who is promoting them? It didn’t seem to be bothering the primary teachers at the workshop. It seems to be an issue with the Communication Skills course at the colleges. I still have to investigate that some more. I’m confused. Things that I had anticipated could be problems, but I hoped would not be, are.

Africa Report #5: 19 November 1993

This term has been a difficult one for me. I have felt quite discouraged and frustrated. On the one hand, I don’t see much possibility of other teachers varying their methods and, on the other hand, I don’t feel that I’m being particularly successful. There are reasons why teachers teach the way they do. I learned that some of the children have difficulty understanding me and what they are expected to do. My classes haven’t always gone exactly as I would like them. When I talk to individual children about their behaviour they find it strange; they expect to be punished, which means corporal punishment. This bothers me a lot. Previously, I just tried to ignore it; I looked the other way and accepted that this was a part of the system and that there was a cultural factor. But I had to think about it more when I realised the children’s expectations might be influencing my own classroom. I’ve included an article from Teacher in Zimbabwe which makes the case for the use of corporal punishment in the context (in order to be fair).

The pupils, in the group discussions we had and in the written feedback I got from them at the end of the term, talk about noise in class. I have a lot of questions about this. Is this my classroom management
problem? Is it a consequence of releasing the children from total silence? Do the children see any noise as bad noise because of what they are used to? Is it bad noise or good noise? In fact, from my point of view, some of it is off-task noise and not acceptable at all, some of it is "normal" classroom interaction and great and some of it is over-enthusiasm—the pupils are on task but too loud.

When I thought carefully about all this, I realised that it really isn’t of much import what I can, or cannot, accomplish [with the children in the classroom]. The other teachers might not have the problems I have. On the other hand, they might. It seems important to find out.

I’ve realised that the marking routine almost determines teaching method. When I first came, I marked the Friday exercises and tests that I was required to give and whatever else I could manage to that was important to me. For occasional straightforward exercises, I had them mark their own work by calling out answers in class. Then I noticed in some exercise books that children had used red pen later, given themselves a mark and written comments like “v good.” I realised then that they expected me to mark all their work. So I started checking this out with other teachers. I don’t know how they manage. I knew our student teachers used to meet this kind of expectation in the schools, but though teachers mark a lot here, I didn’t realise it was that much of a routine. On further investigation, I discovered (through discussions with teachers and through written feedback from pupils) that if everything in the exercise books isn’t marked, parents make trouble for their child because they assume that s/he has not submitted his/her book for marking as required.

I took Mr. Mtisi’s 1A class for some lessons when he went on leave and I tried to keep to the routine. I found it very difficult—to get the marking done (and this was after I was no longer teaching Form Twos and Form Fours) and to plan lessons different from going over the errors and setting the next exercise.

So there it is. I think this is a major factor preventing variety in teaching. There is only one way of teaching. And if there was another way, there would be no time to prepare for it and also mark. To give children textbooks with answers in them is unthinkable. The books with answers are only for teachers. But, surely, there are ways other than the textbook or teacher marking to provide feedback to pupils. I’ve tried to experiment with
this. I’ve called out answers, posted samples of work, and marked group exercise books. I gave the Form Fours who come for extra lessons an answer key and later asked them what they thought about that. They said they found it quite useful as they could then come and ask me about the problems they found difficult.

We started giving extra lessons on Friday afternoons this term. Mtisi and Phiri took the Form Fours, I took the Form Threes, Mabasa took the Form Twos and Phiri took the Form Ones (on a different day). The children were very pleased about this and turned up. The attendance in my class declined through the term but there was still a full class—we started with forty or fifty. We stopped when O-level exams started but some of the Form Threes still wanted to continue; I talked to one boy from 3A who said he was finding them very beneficial. The only problem I saw (besides having other things to do on Friday afternoons) was that it was intended to help the children in the B, C, D, and E classes who were borderline (to consolidate and catch-up on some topics) but as so many 3As attended they tended to dominate the lessons. Consequently, I’m not sure we met what I thought was the original objective.

We also had remedial classes this term. We were going to share them but I think Mrs. Mugedeza did them all.

The idea of a core syllabus did not go anywhere. I missed the departmental meeting at the beginning of the term because of being stuck in Malawi. Apparently, they discussed it but couldn’t come to grips with exactly how to go about it, so decided that each teacher was in the best position to judge just how far s/he could go with his/her class. Then we’ve just all been busy; I don’t think it is necessarily the case that interest has died. I have more or less identified a core approach for 1E. I set paper 2 for the Form Ones in line with this and showed it to all the other Form One teachers. They said it was okay. I decided to let the tail wag the dog. But I still didn’t win—talking to Mrs. Mugedeza the other day she was quite concerned that all Form Ones be at the same place next year so I committed myself to completing all the chapters in the textbook even if it meant extra lessons in January.

I went to 4B at lunchtime on Tuesdays, Wednesdays, and Thursdays this term. One day I was just available for tutorial help, another day we worked on paper 1, and the other day I gave a specific lesson. We did statistics and probability this way; last term we did a unit on linear programming.
during the mid-year exams. However, only a handful of students participated. This was my way of assuaging the guilt I felt at not “covering the syllabus” with the whole class. In class we spent more time on matrices, vectors, and transformation geometry than the other classes. I’m not sure how good a solution this was. Certainly one couldn’t expect other teachers to devote that much time to extra lessons on a regular basis.

We had a consultation day with parents on 16 September. I was busy from eight in the morning until after four in the afternoon, non-stop. It was awful to try to explain to parents why their children aren’t doing very well, especially when I’m not at all convinced we’re doing our best. But of course if we didn’t do that and used assessing for teaching and didn’t model the mid-year on the O-level examination parents would think their children were doing okay and would get a rude shock when they failed. But then, they just might do better. But who’s willing to gamble? I couldn’t talk to a few parents; some didn’t talk to me, but the children said that they understood. In a few cases the parents said that their child did not understand me in class, which made me feel quite bad. With one parent the implication was quite clear, I thought, that the kid would be better off if I were not his teacher.

I keenly felt the pressure I think other teachers feel. Some parents asked me why the work wasn’t all marked and I could see, thumbing through the exercise books, that there weren’t red marks on all the pages. It didn’t look good. That’s why the kids write nonsense and the teachers make red marks; it looks good if one doesn’t look at it too carefully.

I tried to point out the kinds of errors children make and kept talking about the lack of background skills and knowledge, but part way through the afternoon I really wanted to get up and run away. Sometimes, I really had nothing to say and found myself saying the trivialities: “Work harder, be conscientious, ...” I felt angry inside, it’s so senseless! It’s so easy when you’re in the hot seat to want to blame the child.

I tried to get the children to comment, without success. A few said there was no problem, when there so obviously was. Most said nothing, or said they must “study harder, revise their work.” ...
I came with my bag of tricks thinking that more active learning would help passive but willing students learn better. ...

The majority of our students cannot pass O-level, we know it and yet continue to teach them as if they could. We don’t adapt to them. It’s insane. I think this may be unique to Zimbabwe, as “developed” countries have alternatives and “developing” countries select their students. I never experienced that personally before as St. Augustine’s was a top school and GTC set and examined its own curriculum (in conjunction with the university). Though we knew what conditions (I don’t mean material conditions) were like in the schools, we didn’t work under these conditions in our own teaching at the college and we were trying to effect change through our student teachers. The system swallows them [new teachers who want to do things differently] up though.

This is the last week. I’ve finished marking paper 1 and paper 2 for the Form Threes (I have Form 3D; they go A-E). It’s so educationally wrong that I almost cry. It’s like training beginning athletes to high jump by setting the jump at Olympic standard and saying jump! again, and again, and again. I don’t want to return the papers; I don’t know what to say to the students. ... Why must we use the same standard for the teaching and learning process, even if they are to be judged by the same standard in the end?

We are going ahead with the planning for an in-service workshop for the mathematics teachers of our cluster of schools at the end of January. Mr. Shiri is quite keen about it. I think it can’t be a bad thing to bring people together and to promote the cluster concept. But I’m not sure the real problems will be discussed and addressed. I will display teaching aids; particularly I want to focus on symmetry and transformation geometry and include local things I’ve collected like material, wrapping paper, wire toys. ... I think I will also play the isometry game with the teachers. But that’s not really where it’s at for teachers. I thought providing more resources and teaching aids would be helpful, but like Phiri says: “Teachers know what to do; that isn’t the problem.” It’s much, much deeper than that. I think the workshop may be just another case of misplaced aid but it’s still important to go ahead, I guess. We’ll all learn from the experience.

Will an alternative curriculum make it easier for teachers to adapt to the children? I’m not sure. ... The education officers do exercise book
inspections and reports. They have to ensure that it at least looks like the job has been done. The system must be accountable; it must be seen to be doing the job. But what about the professional, caring teacher? It's putting him/her in a straight jacket. I haven't been, I guess because of my position as a researcher, but what would happen if I stayed? I can't say that I have been more successful than the other teachers; I have little evidence that the activities actually helped the students to learn (although I still believe it) and not meeting pupil expectations about marking and discipline has certainly made it more difficult for me to be effective. If I stayed, would I be pressured by administration to meet these expectations? Would I succumb on my own? How would I come to terms with the system? An alternative curriculum, which may be in the works, will not of itself address the issue of teaching method and pupil learning.

Africa Report #7: December 1993

... My problem is that, even without any change in the structure of secondary education or the syllabus, I can't really accept that we can't adapt our instruction to the pupils we have in front of us to maximise their learning. Is this just a cultural and/or educational bias on my part? (What's the difference?) Does it reflect a lack of understanding on my part of the reality of the situation?

The following two chapters explore the views of students (Chapter 6) and teachers (Chapter 7). The interviews with teachers and written comments from students provided extra insight to issues arising out of the teaching experience documented in this chapter. The questions corresponded closely to the categories which were subsequently used to organise the data: teaching resources, group-work, mathematics club, marking, language, and communication. Themes which arose out of analysis of the data are teaching methods, classroom discourse, assessment, and curriculum. These themes are used as organisers for the discussion in Chapters 6 and 7.

By the end of two terms in school I felt good about many of the activity-based lessons I had with the students. But my students were not doing any better on tests and examinations than students in other classes. I was giving extra lessons to the students in my Form Four classes who felt they had a chance of passing the O-level examination because I had not "covered the
syllabus” in class. The students were very cooperative and worked well in groups doing the activities but there was a problem with “breaking the silence.” Students were uncomfortable with “noise” in the class—more so than I was. The mathematics club just fizzled out after an initial surge of interest. Why? What did the students think about my teaching methods?

I realised towards the end of the second term, partly from our class discussions, that I was having more difficulty communicating with the children than I had thought. To what extent was language of instruction a factor limiting my effectiveness? Were the children reluctant to speak out in class because of their English? Could cooperative group work help the children to articulate their thoughts if they were uncomfortable with the noise generated by discussion?

I was increasingly frustrated about the testing and marking routine. When I did not follow the same marking routine as the other teachers, some students were disappointed; they expected me to mark their books every day. When test results were so low, it was difficult to use them to guide further teaching and learning. Why was it not possible to adapt our instruction and assessment to the children we had in front of us?

The teachers felt that their major responsibility was to the children who had some chance of passing the examination and that the best way to fulfil this responsibility was to “cover the syllabus” with all the children. What did the students think about this? Would they support a core curriculum?
Form Twos measuring using a scale drawing
"I quickly understand it because I was the one who was taking measurement" (p.103)

Form Threes measuring using trigonometry
"when writing I remember about the activity we did, for example, when we measure the flagpole" (p.103)
the mathematics club

"... we don't come to school to read books only but we must also have some games to do" (p.108)

the mathematics club

"we didn't learn anything better we were just playing cards" (p.107)
Chapter Six
Students' Views and Problems

This chapter is based on students' written comments. The responses are from my classes (1E, 2C, 3D, and 4B) and from Mr. Phiri's classes (2A, 2D, 3B, and 3E). At the end of the academic year (my second term in the school) we obtained written feedback from the students about specific activities we had done with them and about the issues which had arisen during the course of the study.

We had previously held class discussions with each of these forms, asking them about their difficulties in learning mathematics. The discussions helped to formulate the questions we asked later. I wanted to know: Did the teaching aids and activities help them learn? Did they go to the mathematics club and what did they think about it? Did they value working in groups and what were the difficulties? (They had indicated in the class discussions that all was not well in the groups.) Should the teacher mark all their work? Did they understand me? (The issue of language surfaced in both 1E, 2A, and 3D.) Should classrooms be quiet? (Noise was a concern in all my classes.) Was it more important to cover the syllabus or to take additional time to learn? (The students had indicated that they were confused by the amount of information they were expected to learn in all subjects.) The session was prefaced with remarks about the purpose of the exercise and about the questions, giving examples to make the questions clear. The students were encouraged to write as much as they liked about any, or all, of the questions. (Refer to appendix F.)

The following discussion of student responses centres on assessment (marking routine), classroom discourse (language of instruction and group-work), teaching methods (group-work, activities and teaching aids, mathematics club), and curriculum (covering the syllabus). It treats my classes and Mr. Phiri's classes separately in order to highlight similarities and differences in the responses.

Assessment: Marking Routine

Pupils were used to having their exercise books marked every day. They were clearly disappointed that I did not follow the usual routine with regard to marking. They gave a number of reasons why they wanted their books marked: when they make corrections, seek help at home, or revise their work, they have to know what is right and wrong; it is my job and will
help me know what their difficulties are; it encourages them to do their daily work; they can not be trusted to mark their own work; when the books are not marked, parents think the children did not hand in their work.

The teacher must always mark our books and all our work because when we get home our parents want to see our books and they saw that the books are not marked they say you don’t hand in your book. (Sipiwe, 2C)

In marking you’re only marking tests why? Since you came here at Kwelo Sec you give us more work for daily exercise and books are not marked. This affects me and I’m shy to give my books to parents because they will think I’m not serious with education. (Josephine, 3D)

The quotes reflect a theme common to all comments; whatever else students said, they also said that their parents looked at their books and made trouble for them when the work was not marked. Angst over the fact that I did not mark the exercise books on a daily basis was central to the feedback from my students.

They seemed bewildered as to why I did not mark their exercise books every day.

But in our exercise books we need marking as you said it’s that you are not lazy so do it coz if our parents looks at our books they thought we are not handing in for marking. (Tinashe, 3D)

On marking they must be a bit improvement because our parents are troubling us because of these unmarked work. They say you don’t hand in your books especially exercise and homeworks. On tests not any comment because you really mark. Maybe you don’t have enough time to go through our books because you are always busy. I don’t know, I can’t force you. (Daniel, 3D)

Others also acknowledged that I did mark the Friday exercises and tests and that the work I marked was marked thoroughly.

On marking books you are very good and you correct our mistakes. But some of the work I wrote is not marked but you are a good marker on test and exercise and you gave us more work so that we can know how to solve the equations. (Shamiso, 3D)
The tests you gave us are good. There are no problems and you mark fairly and every topic we learn you gave us the test and it also covers the work we have done in those weeks. (Alleta, 3D)

A few students in 3D thought it was all right to mark their own work sometimes but this was because “the books will be many” and I would have little time for marking. In their view, because I was not lazy, I must have been too busy; they did not appreciate that I had did not want to mark their work daily. From the time in class and the weekly tests and exercises I knew what their difficulties were. I wanted to spend time planning and organising the lessons.

Some of the comments indicated that if students know their work is not going to be marked they will become “lazy” and not do the work. In 1E, many said that the “other” children “cheated.” They would leave part of the page blank and fill in the correct answer when the work was discussed in class.

Ourselves can’t help us to learn because some of the childrens they are going to write question and wait for answers they can’t work for theirselves. (Elizabeth, 1E)

One student in 2C remarked:

I say the teacher musn’t mark all my work because I must learn to know if I have wrote something write or wrong. (Nomsa, 2C)

Another said the teacher did not have to mark all the work but that we had to discuss the work in class and another that “you do revise with us so there is no problem.” These were decidedly minority opinions. To the students, marking of daily exercises by the teacher was integral to the teaching and learning process. Elizabeth’s comment that “ourselves can’t help us to learn” is at odds with the methodology statement in the syllabus which suggests children “check and criticise their own work.”

In contrast, students in Mr. Phiri’s classes appreciated that he was very conscientious about the daily marking. For example:

The marking of books helps very much and the doing of corrections make me to know the problems which I got wrong. Giving homeworks help very much because I go get help from my brothers to work the problems. The Friday tests are good they
show us if I had understand what we were doing the whole week. (Memory, 3B)

The majority of Phiri's students agreed with Memory. Students got valuable feedback and ended up with a record of their work which they could use for study.

A few comments from Mr. Phiri's classes, though, indicated that there could be problems with the marking routine.

I can not learn with my book being marked because sometimes the teacher refuse to mark my book when I try to work my problems thoroughly at home. When I want to hand in my book the next morrow it will be written "Send your book for marking." So its useless to me, I mean it can't help me. (Thulani, 3B)

Some students wanted to take their work home rather than hand it in at the end of the class. In order to get it done they did not always have time to think carefully about the work and they sometimes copied the work from one another in order to get the books in on time.

It is better for the teacher to give us homeworks rather than doing the exercises in class (that same period) because time is not on our side every time. With no free periods it is difficult for us to finish up in time; thus we end up waffling just to finish the work not to learn. (Thanks, 3B)

Homework is better because if I don't know something I will ask my brother or my sister so that she can help me to work but the problem is when I com here most of the people took my book and duplicate everything I wrote but they don't know which is correct or wrong. (Theresa, 3B)

No I cannot benefit from teacher's mark because sometimes I can get even a good mark maybe I can get it from other's book So it will be for me to make sure that I am able to go through the exercise. (Donewell, 3B)

The marking was very helpful to those who did the work but the pressure to hand in the books for marking meant that some children copied the work of others, rather than trying it themselves.
Classroom Discourse and Language of Instruction

My students, especially 1E, were disturbed by “noise.” They expected the classroom to be quiet.

People should be quiet or answer and ask questions and not talk while working. (Muchaneta, 1E)

Pupils should be quiet in class while the teacher is teaching and everyone must be asking questions if he or she do not know the answer as you have to answer and the teacher will help you. You have to ask questions if you don’t understand. (Flora, 1E)

Peoples must keep quite when the teacher is in the classroom because it help us to understand what the teacher says. People must answer question and ask. They must not talk while the teacher is teaching. (Vimbai, 1E)

The students comments describe what they considered to be the ideal classroom discourse. In reality only a few answered questions, fewer asked questions, and some students did not always listen to me.

Students’ comments also explained why so few were involved in the ideal classroom discourse described above. Some were “shy” to speak out.

If you speak wrong answer others will laugh at you. ... To ask question I will be shy because all children will be looking on my face. So there is no need for me to ask some questions. (Silibaziso, 1E)

I don’t ask questions because they have the system of laughing at you if you make a small mistake in speaking. (Alleta, 3D)

Some were also having difficulty understanding what I said. I had an accent and I spoke too fast. So they stopped listening to me and started talking amongst themselves.

The problem is that your language can be difficult for us when you ask a question. (Keith, 1E)

Pupils make a lot of noise because English is difficult to them. Others don’t even listen to the teacher, don’t even ask questions. Few ask. (Angelah, 1E)
Is not help when people are talking all the times people move
the chair and making a lot of noise. I am not ask answers because
I am not understand what you are saying people a lost for noise.
(Saliwe, 1E)

The students' self-consciousness about speaking English and my use of
English both served to limit class discussion.

Students who had less difficulty with English and wanted to participate
became frustrated.

Some of the children in our class talk Shona but they know you
dind understand Shona. I have got a problem. If you teaching
some of the words you speak I can't hear them because the
students are talking and you are too fast when you are teaching.
(Elizabeth, 1E)

As a consequence of these language difficulties and "noise" in the class many
pupils were confused, especially in 1E but also in 3D.

Sometimes I understand what to do. Sometimes I don't
understand what to do. I don't understand what to do when
some pupils are talking. (Robert, 1E)

Pupils should not make noise in class so that other can hear the
instructions from the teacher. Because some of us are not able to
hear the instructions and we end up doing our work without
knowing what to do because of noise. (Joel, 3D)

Other students claimed they did not have difficulty understanding me.

I answer question and I don't ask questions not because I know
but I understand what you say and what you teach.
(Nyaradzo, 3D)

The language is good and everyone understand but some cannot
speak it that's the problem to most students at school.
(Reminosy, 3D)

Yes I understand what to do because I was lesenng all the words
you said. Some children will be irritating and they will not
understood. (Brenda, 1E)

Students who could understand were annoyed at those who did not listen.

Although some people can't understand her language clearly ... I
see nothing wrong with her language. The other thing is some
people make fun of her when she speaks, that is her pronunciation of Shona names which makes them don’t understand nothing. I hate that because they disturb us when we want to learn by making their funny noises. (Constantine, 3D)

I don’t think communication is a problem. We are learning English and now in form 3 and we still can’t understand English? Impossible. Its a matter of other people would be talking and they don’t listen and then you give the blame to the teacher or language. English is English even if the pronunciation is different you must understand. The same applies to Shona. If the teacher comes day in and day out giving you work and you don’t do or read it, how come you look forward to pass. Even if you don’t understand the communication its better to study or revise the work rather than just come and sit. (Simon, 3D)

A few suggested that I put more pressure on those who did not listen.

I think for those who don’t know how to speak the English they must learn how to speak English. They also don’t licen when you are teaching ... They must be written their name down and get punished. (Farai, 1E)

But how could I punish them for not understanding me? Or for not learning? Especially if it meant corporal punishment. I had no solutions. The students’ comments indicate that language was certainly a significant contributing factor to the problem of “noise” and that the problem was compounded by my inability to respond as they expected.

Language of instruction was less of an issue with my other classes, 2C and 4B, and with Mr. Phiri’s classes than it was with 1E and 3D.

Classroom Discourse and Group-work

The majority of students in my classes valued working in groups. They articulated two major advantages over working as a whole class—greater participation and peer support for learning.

As noted previously, some students were reluctant to speak out in whole class discussion because others might laugh at them.

... when someone asks a question they have tendants of laughing to that student instead of paying attention to the question so that very student can totally fill out of place because of laughter. (Patience, 4B)
Some children who did not participate in whole class discussions did participate in group activities.

This also helped me because I got more skills from others and also even participated in class because of group work. I think we should do more of it so I also could be helped. (Angelina, 3D)

One reason for greater participation was that they could speak Shona in the groups.

Sometimes you can not know how to speak English properly so if you are in groups you can even asked your question in Shona to understand. (Donald, 3D)

Also, they could understand each other better than they could understand me, whatever the language of discourse.

When we started working in groups it was becoming better. Working in groups is helping me a lot because I understand what other pupils tell me. The group discussions help me learn because the tone our teacher uses is very complicated that I end up hearing only a few words. This doesn’t mean that I can’t speak English, no I can speak but the way she pronounce her words is very fast. (Mercy, 4B)

I think on my own that group work is good for us because other students don’t listen when you are talking but when we are in a group each one of us must say an answer so everyone enjoys the group work. If the other is on duty to answer the question if she/he fail we tell that person when we know, but when we don’t we call the teacher and the teacher help us as each one of us is listening. It help us very much because when we are in a group we give each other a duty to work the answer so they will be no one playing everybody will be busy. If there is noise it means people are not working. (Ethel, 2C)

A major advantage of working in groups, then, was that “... everyone will be participating in giving answers or his points. ... everyone will be thinking.” In my classes they could communicate with each other more easily than with me.

Another theme in the students’ remarks was that they could share ideas and help one another.
To work on the group book helps us to learn because we joined our brains together. (Elizabeth, 1E)

It is good to work in group work becoz it will help others who do not know what to do. It helps me learning because we will be sharing ideas in our work. It helps me learning because everyone will be participating in giving answers or his points. There are no problems in group work because everyone will be thinking. (Joseph, 2C)

I think it is good to work maths problems in groups because it helps some of us to think because working the problems alone may be difficult so when people are two or more the problems are easy. This also helps to improve the chances of thinking in that you may learn other ideas which some students might have. ... it makes someone have wider thoughts. (Oracle, 4B)

Greater participation meant more children were thinking about the mathematics. In addition, with help from others, students were able to do problems they could not have done by themselves; the difficult problems were easier.

The main problem students encountered in groups was that not all children were on task, particularly when groups were large. Some talked about other things, which distracted and frustrated others.

There is a disadvantage on group work and the disadvantage is that some of the group members didn’t want to participate they just whispering like young dogs eating sadza with milk. (Tendai, 3D)

It helps us because we will be discussing each other but we need small groups so that we teach each other easily and if we make a large group some students will be making noise and sometimes 2 or 3 people are the only one who will be working the problems and the rest will be just making noise. (Alleta, 3D)

It appears students were not necessarily more supportive in small groups than they were in whole class discussion. Some “good” students begrudged time taken to help others.

I think that working in groups is quite helpful especially when the two groups are according to ability because when there is a group of people who know maths well they will be sharing ideas, which makes the subject easier. When the groups are
mixed up some kids have a difficult time in understanding thus it makes other students stop concentrating and try to explain to their fellow classmates who do not understand. (Munyaradzi, 4B)

In groups some students discourage others but they do not know it was just a minor mistake. When a student is discouraged he/she will not participate according to what he/she could have done in fear that he/she will be discouraged again. (Takunda, 4B)

Perhaps some students in the groups were off-task because they found it difficult to participate in the group [were discouraged from participating by their peers; were afraid].

The better students often preferred to be grouped according to ability or achievement.

This sometimes help us learn it depends what kind of students you are working with, some students are playfull when it comes to groups. Our groups should be ranged like those who can do better should be grouped together and those who don’t do better can be taught in their own groups. (Nyaradzo, 3D)

... at the beginning I could not really see its value as we were put in groups (mixed with other lazy and noisiest people). But to my surprise I now support the idea of grouping students together because the groups were now arranged according to their performance. I feel our group is one of the strongest because everyone will be participating, sharing ideas, and I feel this should be continued. In my group students are not hesitating to ask or fear to say something is wrong. It’s one of the quietest group. No one is disturbing in the group. (Taurai, 4B)

The ability groups worked well for the higher-achieving students. Most students preferred to work in mixed ability groups, though, saying that those who knew could help those who did not.

There were no problems when we were working as a group and everybody participated in that group. The best groups are the mixed groups as it helps those who don’t know to ask those who know. The ability groups are very discouraging to other students in my own opinion and I have seen this in our class. (Ronald, 4B)
When those with lower marks were grouped together they do not know what to do.

This does not help me in learning because the groups which I am in, there is no-one who can help me because the question which we answer everyone in that group said I don’t know how to solve the problem so I think there is a big mixing. (Fungai, 3D)

In contrast to the higher achievers the middle and low-achieving students preferred mixed ability groups.

Some students would have preferred not to work in groups at all.

Group work to some extent is good but I personally don’t like to work in groups especially when it is in class because (1) It encourages noise which results in lack of concentration (2) Pupils tend to discuss things which do not concern what they should be doing (3) Group work spoils pupils in the sense that pupils get used to working in groups and when it comes to examination the pupils cannot think he has been under the assistance of other pupils (4) Group work makes pupils not to finish but let other students think for them (Charles, 4B)

At times this is the other ways of teaching but I don’t see them profitable just because there are some who are even selfish during these group times. So I prefer self deeds mostly and class discussion. ... practice makes perfect so I was used to everyday homework and exercises which are marked in class. (Margaret, 4B)

I think group works are not as efficient as they seem to be. Although I found group works to be of little help if they had been carried out efficiently they could have been of great help. When we were told to sit in groups some time was wasted as some students moved slowly. It also created much confusion as some students were making much noise. ... I think in order for students to participate effectively they should work individually and the teacher helping each pupil until the pupil has full understood. When working in groups a teacher might not notice the difficulty a pupil might be facing. But seeing one pupil after the other the teacher might notice the problem a pupil might be facing and teach him/her. (Takunda, 4B)

Some students had good reasons for not wanting to work in groups. Perhaps they would have felt differently if the groups had been better organised and functioned better.
Most students in Mr. Phiri's classes were also positive about working in groups. Whereas I used groups on an ad hoc basis to do activities and/or to use the teaching aids, Phiri had permanent groups who sometimes worked on exercises together as well.

Group work help me because I am always free when I get into our groups. So that I can easily asked questions to my friends I do not feel asking rather than to the teacher. And I am able to partispet in groups. (Donewell, 3B)

Group work is excellent because members of each group will be helping each other in solving a problem. It is also an advantage to those students who are not brilliant to see how the brilliant students work the problems. Groups I think should be composed by mixed ability so that others may benefit from others. (Gift, 3B)

There were also problems in the groups, however. Some group members were "lazy and not showing much concentration" or "playful and talkative," which frustrated others.

... some do not participate, they want to obtain marks which they never had worked for. This bores [angers] me so much but even if boring it make me understand better than if I am working problems alone. (Butholezwe, 2A)

I need group work but our problems are some people do not communite with others but they want to copy. (Banna, 2D)

As in my classes, though, some students became discouraged when they tried to participate.

To me it was useless when we were discussing these problems you give the writer an answer but he/she doesn't write it down why? so at the end I get fed up and just keep quite. And they are some who will wanting to do everything. (Sibuyisa, 2D)

Despite the problems they identified, the dominant feedback from both our classes was that working in small groups helped them to learn.
Teaching Methods: Teaching Aids and Activities

According to students, the practical activities were helpful because "... we will be doing it ourselves and this make us understand."

I think the activities which we did were good and the activities made us understand what we mean by e.g. scale drawing and they helped us a lot to learn and understood very much. It was worth taking the time to do the scale drawing of the flagpole because it made know what we mean by scale drawings. (Elson, 2C)

It was wonderful to use geoboards, mirrors and tracing papers because we understand properly what we are doing using the materials. (Tawanda, 4B)

A number of students also said that they were less likely to forget the concepts when they had learned them by doing practical activities. Later, when "writing" an exercise or test, it helped to recall doing the activity.

Activities are good to me because they help me to understand things quickly and we did not forget things which we have done in the Maths. ... The activities that we do of flagpole I quickly understand it because I was one who was taking measurement at that activity and write them down. (Tinashe, 2C)

This help me because sometime when I din’t understand, when writing I remember about the activity we did, for example when we measure the flagpole. (Nobert, 3D)

The activities, then, helped students to understand and to remember what they had learned.

Students also used "understand" when they spoke about using the teaching aids.

They helped me because the cards, the shapes, e.g. where making ours understanding more. (Joanne, 1E)

I think the teaching aids were very helpful to us as students doing Maths. The Aids helped us in visualising some maths problems which will be proving to be difficult to us students. Aids made some difficult problems easier. Aids, in my opinion help very much in learning because they make you understand better when the teacher explains. (Ronald, 4B)
At least some children, then, appreciated learning mathematics using teaching aids. They were "seeing what was going on." This was helpful when the teacher demonstrated using the aids, but was even more helpful when they used the materials themselves.

I may say that it helps you see the object and understand what the problem is and how to solve it because of the object. (Simon, 3D)

I was able to shear using rubber bands on these geoboards, and it was easy for me. The use of mirrors enabled me to reflect the transformation problems. It was much easier to use the mirrors when solving the problem, and this helped me to learn mathematics. The use of geoboards also helped me in knowing vectors. (Senzeni, 4B)

These students found that using concrete objects made it easier for them to learn mathematics.

A few students, although conceding that the aids were helpful, had reservations. First, they were not going to be able to use these resources on the examination. Second, they were concerned that we were falling behind the other classes because we took time to do activities. This meant we might not "cover" all the topics or have time for revision.

This can help us but the trouble is that in the exam you are not allowed to use calculator or trundel wheel which use on flagpole. ... activities it waste a lot of time and we are behind with other class. (Nkosana, 3D)

Geoboards were quite helpful in learning. Mirrors and tracing papers were also helpful but they also tend to spoil pupils in the sense that people get used to using them and then come examinations, no geoboards, no mirrors, no tracing papers and the pupil just know nothing, "poverty waiting for him/her." (Charles, 4B)

To students and their families, education is seen as a way out of poverty. With the stakes so high, these students worried that the teaching methods I used might jeopardise their future.

Nkosana and Charles still found the approach helpful; a few others would have preferred to learn from the "theoretical" approach used by other teachers.
Instead they [the teaching aids] disturb us such that we will not understand the things. I think they must be brought only for the introduction not for every lesson because what we write on the exams didn’t concern such things. We must be used to drawings from the board. (Margaret, 4B)

I think it is better to learn how to tackle different kinds of topics. Instead of using mirrors and geo-boards, I think the best thing is just to know the formulas and how to work out different types of questions. (Cephas, 4B)

It [the theoretical approach] is helpful because if you lack on one topic the risks of passing are present because there are many topics covered. It also helps because there will be time for revision. (Marjorie, 4B)

Teaching theoretically meant that the syllabus could be “covered” with time for revision and the students would be better prepared for the examination. Yet another student thought there was a compromise solution.

I think the use of instruments eg geoboards, mirrors and tracing papers is a good idea because: (i) it is faster, for example when we want to reflect an object we just put a mirror, when we want to rotate an object we can use a tracing paper (ii) when using geoboards it doesn’t waste books for example one can do the problems on the geoboard and when he/she is satisfied with the work, he can now transfer it in the book. Especially for me the instruments help me a lot because it made life easy. But I do not know whether the tracing papers, mirrors and geoboards are allowed in the examination room. If they are allowed I think it is the best way to use geoboards etc. If they are not allowed they can be used firstly when the teacher is introducing a topic and when the pupil are familiar with the topic then we can stop using them so that pupils can do without the mirrors etc. (Aleck, 4B)

Aleck saw advantages to using the teaching aids which did not conflict with preparation for the examination.

Most of the feedback from my classes about the teaching aids and activities was positive. The negative comments were related to concern about success on the examination.

Phiri’s students also said that working practically helped them to understand and to remember.
They helped me to understand the lines of symmetry more clearly by using physical objects. We understood scale drawing by actually measuring from a real pole and that made me understand better than just explaining and drawing. (Tichaona, 2A)

I understood because to do activity is better than to be told only. We were to find lines of symmetry of quadrialearials and under shapes which was very interesting so much. We were to reduce the shape of something into a small one which helped so much becoz when we were in form 1 we didn’t understood, but when we did it we were to understand far much better. (Karen, 2A)

We found that you can remember what you learnt about. Even in the exam e.g. on statistics we used marbles with bright colours, for my own view I found it helpfully cause if I hear the topic statistics I think of marbles with bright colours. On activities you can understand by seeing that project if you got understand the teacher’s explanations. (Simbarashe, 3B)

Doing it themselves was better than being told and using objects was better than drawings.

The activities helped me because I understood all the stages and exercises in the textbook because we were doing it ourselves and understood how to come up with a shape on the geoboard and how the lines of symmetry are shown on a geoboard. (Victoria, 2D)

Aids helped me better because it is better to use objects than to be just told or taught things which appear in the textbook. On my own opinion I see it better to use objects rather than drawings. (Togarasei, 3B)

And at least one student felt that understanding the material would help on the examination.

They helped very much especially during scale drawing and when understood the chapter very much that if asked during the exams I would do quite well. (Robson, 2A)

Like Aleck in my class, Robson did not see a contradiction in using the teaching aids and preparing for the examination.
Teaching Methods: Mathematics Club

At the mathematics club, the Form Fours played the isometry game and all forms tried various cube puzzles. The Form Threes and Form Fours did the Pythagoras' puzzles. The puzzles were intended as examples of “non-routine” problems. Some Form Fours tried probability activities with dice and cards (without any guidance) but ended up playing card games instead. Form Twos did some work with the calculators. They answered riddles corresponding to the result of a calculation and worked through the calculator section in the new edition of the Form Two textbook. Form Ones put the playing cards into sets and made tiling patterns with the pattern blocks. All forms played “crazy eights” with the cards.

It was primarily students from Phiri’s 2A class who attended the club. The most common response from them was that playing games, doing puzzles, and using calculators were a waste of time.

I enjoyed going to the club but it did not help me because something like playing cards, working math using a calculator I did not enjoy it would be better if the teachers in charge could ask us questions which are a problem in class so that we can have more studies about the difficult chapter in the syllabus. (Robson, 2A)

It was boring because we didn’t learn anything better we were just playing cards forming shapes I think here teachers must try to do something productive not just wasting our time coming for nothing. We must be given work to do. (Munyaradzi, 2A)

Some other comments were: “I soon rejected it” and, “actually, I hate it.” “We thought we will be doing mathematics” and “learning” but “we would do games and other thing other than learning.”

A few comments were more positive.

Many students like me do benefit a lot from the Maths club because the work given makes you think no matter how dull you are. Most of the time the members are left with anxiety when it is time up and they haven’t finished their work. The materials at this club are great. Keep it up. (Gift, 3B)

I went to the club because I discovered that it helps to train certain activities or brighten your brain with the puzzles we did. (Simon, 2A)
It help us to know many games we don’t come to school to read books only but we must also have some games to do. (Janet, 2A)

These comments were the exception though. Most students saw little purpose to the activities.

I don’t attend because they are not concentrating on math but on chess. Please may you use it for extended maths. (Nkosana, 3D)

Most children felt that a mathematics club should be for “extended maths.”

Very few of my students attended the mathematics club. 4B had a scheduled English class on Wednesday afternoons, so could not go. Some students from my other classes had to go home after school, others were already attending other clubs. Most comments about the mathematics club from my classes were not based on first-hand experience at the club.

Many students confused the club with the extra lessons given on Friday afternoons. For example, some students remarked that they had not been “chosen” for the club. This was because only students with passes or borderline failures on the mid-year examinations were expected to attend the extra lessons.

Maths club helped me because we covered many topics which I did not understand when our maths teacher was teaching and when we were working in groups. (Susan, 2A)

Students found these extra lessons valuable.

This is where I got some better formulas of Maths. People will be sharing ideas—i.e. best Maths students from other classes and it would be interesting. I managed to get formulas like $A = \frac{1}{2} ab \sin C$. This was a better formula than $(1/2 \ b \ h)$ because in some triangles there will not be a height. I also got the formula for calculating the total angles of a regular polygon $(2n - 4) 180^\circ = (n - 2) 180^\circ$. That’s some of the things that helped me. This is what I got on Friday afternoons. I am failing to attend Maths club on Wednesday afternoons because of an extra English lesson 3:40-4:00. (Taurai, 4B)

Taurai knew the Friday lessons were not the mathematics club. Like Susan, though, he found them very helpful.
Another comment reflected my own feeling that we did not manage to prepare adequately for the club.

Good activity to do although a few pupils turn up for it. It seems pupils are losing interest in dealing with the same things.
(David, 2A)

By most accounts, the mathematics club was not a huge success.

**Curriculum: Covering the Syllabus**

We asked students for their thoughts about "covering the syllabus": was it better to move through the material quickly, leaving time for revision, or was it better to go more slowly, leaving out some topics, but learning the material better? The question was related to our own exploration of the feasibility of a core syllabus.

Not all students responded to this question. The responses we did get were mixed, often diametrically opposed.

It is good to go through topics slowly because we would understand rather than learning fast because as a result we will end up confused by the topics and we would fail because of that.
(Nelly, 2C)

I will fail with maybe a D or E because we have not completed the syllabus. (Chelaje, 4B)

These comments summarise the curriculum dilemma nicely—they will fail because the pace is too fast; they will fail because the pace is too slow.

The major reason students gave for covering the syllabus quickly was to allow time for revision.

The syllabus must be covered even if some did not understand and then revise the work again or to revise the topics which most of the students did not understand. (Reminosy, 3D)

In addition, if all topics are covered, students have choice on the examination questions. If they do not know one topic, they will know others; otherwise, "we may concentrate on one topic and it may never come on the exam" while "some may never understand the topic at all" and "we might not cover the topics which are difficult to us."
Students wanted to go slowly in order to understand; otherwise, they could not absorb the information and felt confused.

It’s not good to rush on finishing the syllabus whilst students don’t understand, because it will confuse the students because many topics will be available and also even those brighter students still won’t remember some of the work which was covered, because the teacher will only be rushing on to finish the syllabus. (Miriam, 3D)

... it doesn’t help to cover the whole syllabus leaving some students without an understanding. I mean understanding is much more important than pushing without understanding. (Musa, 4B)

It is nothing to say we have covered the syllabus while you know nothing. So I support the rate at which we are moving because everyone will have understood e.g. (matrices, vectors). In these by now I don’t have any difficulties because this was done for a long time and I was able to absorb. (Taurai, 4B)

Other students commented that the teacher should decide what is most important, choosing “chapters that appear most frequently” in the examination and topics which “carry many marks.”

Two students felt that the onus should be on students to get extra help if they needed it.

If we cover it and we don’t understand it is our hard nuts to crack by asking the teacher how it is done. (Monica, 3D)

On other topics the teacher should not teach willing students. Some students would be rushing home to finish homework and thus cannot attend the out of time classes. Instead the teacher has to do the work in class spend some time on it and if there are some who don’t understand should go and see the teacher. (Eliya, 4B)

Although Eliya did not approve of my solution to the curricular dilemma, it was the students in 4B who felt they could pass who were the most “willing” to come for extra lessons.

One student had an interesting comment.

I think the syllabus must be covered thorough for knowing complaints from the students after the exam. (Nomsa, 2C)
In the initial interviews the teachers had also made this point. An important factor in the rush to cover the syllabus was that parents could not then attribute failure in the exam to the teacher’s failure to present the material. Phiri’s classes, like mine, were split on the relative merits of a core approach and “covering the syllabus.”

The speed we used in covering the syllabus was very great. It helped us to ask the teacher to revise some topics which we do not know. It’s no use in taking a lot of time in finishing the syllabus and you end up with having little time for revision. 
(Saizi, 2A)

The syllabus is too long that sometimes the teacher will be too fast so that you can manage to finish the syllabus and we are confused. (Tinarwo, 2A)

However, Tinarwo was the exception in 2A. More children shared his views in Phiri’s other forms.

**Summary of Students’ Views**

Students were upset about my marking. They gave a number of reasons but the major one was that their parents gave them trouble if their books were not marked daily.

Students found working in groups to be helpful because they could “share ideas,” because they felt more comfortable speaking out in a group, and because they were having difficulty understanding me. In the groups, other students could explain things to them; they could also speak in Shona. On the other hand, many students were frustrated by the noise level while working in groups.

Nearly all students who commented about the activities said that doing the activities helped them to “understand.” Some thought that they were less likely to forget what they had learned and others that using the objects helped them to solve problems.

Comments from Mr. Phiri’s classes about teaching methods and curriculum were similar to those from my classes. Comments about marking and classroom discourse differed. Views expressed by his 2A class were often different than those expressed by our other forms.

What emerged was a picture of two groups of mathematics students in the school—those students who expected to pass the examination and those
who did not. Both teachers and students themselves used the same labels—a student was “fast” or “slow,” “bright” or “dull,” “good” or “weak/poor.” Whereas in my view, these labels are an oversimplification, they are convenient for summarising the students’ views, in particular for gaining greater insight into the feelings of those who did not consider themselves successful.

First, a snapshot of the “fast, bright, good” students. They did the work and valued having their books marked on a daily basis because they liked to use them for revision. Their English was good, they understood what was said in class, and they knew what they were expected to do. They answered questions but tended not to ask questions in class—they were more likely to approach the teacher after class. They appreciated the extra lessons. They also appreciated covering the syllabus quickly, leaving time for revision; they did not get confused when the pace of learning was fast. These students had confidence that they would pass the ZJC or O-level examination. Some preferred to work in groups by themselves, where everyone would “try” and everyone would contribute. A few preferred a “theoretical” approach and the traditional classroom routine.

The focus of my project changed, in large part, because of the other group of students—the “slow, dull, weak” ones, who were the majority in our school. We wanted to help them, but how? The following paragraphs explore life in school from their perspective in more detail.

Like the “fast, bright, good” kids, the “slow, dull, poor” ones wanted their books marked so that their parents would not be dissatisfied with them. But they could not do the work.

The problem of homework is that when I at home I can’t even know where to start at. To me homework is helpless to my learning. (Peter, 3E)

... it is also dangerous because you might not work on your own because you will just give to somebody who is able to do so and then write for you and if you come to school you will get all correct but not knowing how to work the problems. And you will see that to work in class leads to no more by tring yourself. (Walter, 3E)
If they got someone else to “write” for them, they could hand in their books for marking and please their parents and teacher, even though they did not know how to do the problems.

These students were reluctant to speak up in class for fear others would laugh at them, because of their English or because they gave a wrong answer. This is why they liked to work in groups; they were more comfortable and they could speak in Shona. They did not like to be put in groups together because they would not know what to do. They preferred working in mixed ability groups. Then they could get help and/or copy the work from others. Sometimes, when they did try to participate in the mixed groups, others discouraged them.

We find problems in group work. The problems we find are not very difficult to solve. Some of us in there do not want to discuss with us they only want to write and send the book for marking. ... In group work I don’t like to work with friends because they will be also thinking about other silly things. I like mixed ability because it help us to learn from those who can afford to pass the test. (Tendai, 3E)

In groups, if they didn’t participate, they often ended up talking about other things and/or copying the work from others.

Few of these students attended the mathematics club.

I am not going to maths club because I can’t able to pass the mid-year exams. I think when I pass my end of year I am able to join maths club. (Nathaniel, 3E)

One of the reasons they did not attend the club was that they perceived it to be the extra lessons for which they had not been “selected.”

They wanted to do well; they would have liked to pass maths, but they did not expect to. “I try by all means to pass maths but I fail.” Passing the test seemed out of their control; “only God knows who is going to pass or fail.” So they “just look on tests.”

But I think I have a problem in working Maths because since I started my form 2 I didn’t pass from first term to third term. So I think I can fail because I don’t think the miracles will happen when I startd writing. (Pauline, 2C)
... when it is classwork I pass and I participate. It is difficult to me mathematics so when it is test I can't follow any stage sometimes I panic. (Angela, 3E)

They found it discouraging to get low marks all the time.

For tests I write with all my knowledge but I wonder why when I see low marks. Sometimes I lose hope coz when I started my secondary level I didn't even pass maths from marks 52 upwards I only ended to 50. So I see like the subject is meaning less to me to study, but mum I love the subject only that problem. (Tinashe, 3D)

I like the teacher very much and I do most of her homeworks and as a teacher she marks them and I get a zero those zeros bored [angered] me very much and I don't show anyone. (Tamary, 3D)

They were embarrassed as well as discouraged by the low marks. They blamed themselves for their lack of success.

If you always get zeros in classwork and tests this mean that you didn't follow what the teacher taught you. (Tsitsi, 3E)

... because when I get a zero I should give more effort in order to get 10 or 15%. (Nathaniel, 3E)

Activities carried out in class are very good and sometimes we are asked to work in groups so that we share ideas but our empty heads does not keep the ideas for very long time that is at the end of the lesson everyone except the intelligent one will be already forgotten. Our maths teacher tries by all means to make us understand but to me its always difficult at home I try by all means to revise what we were doing in class and I understand it but after 3 to 4 days all will be blown away. The fault is mine and not the teacher. (Tamary, 3D)

When they failed it was not the teachers' fault, or the curriculum, or the assessment; it was their fault—their own lack of effort or their "empty heads."

They wanted to go through the curriculum more slowly so they would not feel so confused and they might learn something.

I do like syllabus coverages, this is if we do it slowly so that it stick to our brain, but not covering it so fast just because we want to cover it. Otherwise some of us would have understood nothing. (Feltah, 2A)
I think the best solution is we must cover some topics so that we may not be confused, that's why most of us fail. (Nokuthula, 3E)

A core approach to the curriculum might help these students.

In summary, many students in our school who wanted to learn were lost and confused. To meet expectations at home and at school, they were expending a lot of effort acting the part of a student and pretending to learn. But they were not learning the mathematics it was intended that they learn.
Chapter Seven
Teachers' Views on Assessment, Classroom Discourse, Teaching Methods, and Curriculum

This chapter is based on interviews I conducted with the teachers in May of 1993 and in January and February of 1994, the feedback I received from Mr. Phiri, Mr. Mukoyi, and Mr. Shiri on Africa Reports, school documents, as well as my field notes which recorded daily conversations and events. All documents were filed with my field notes. The chapter compares and contrasts teachers' views with my own (Chapter 5) and with those of the students (Chapter 6). It explores further the teachers' thoughts about the teaching methodology statements, particularly those recommending activity-based learning and group work. By adding the teachers' perspective, this chapter provides greater insight into issues surrounding assessment, classroom discourse, teaching method, and curriculum. In the final interviews (Appendix G2), I asked teachers to respond to my own growing understanding and to concerns which the children had raised.

Assessment Issues: Marking Routine

I thought that the marking routine was a major factor preventing teachers from varying their teaching methods. The amount of time spent marking left little for preparation. The marking routine also pre-determined a teaching routine of exposition, exercise, and feedback. The student responses confirmed that many students copied from others because they could not do the work, which made much of the marking of questionable value. Nevertheless, after reading the students' comments, I wished I had met their expectations about marking more closely.

I talked to the mathematics teachers, the headmaster, and the education officer about the marking routine in order to further assess the extent to which changes in assessment were needed and feasible. I wondered: Why did teachers give an exercise every day and mark it? Who expected them to do this?

In the final interviews I asked the teachers why they marked all the work, if they thought feedback could be handled in other ways, and how they handled the marking load. Administrators and parents expected teachers to mark daily exercises. A teacher who did not "mark" would not be seen to be doing his/her job properly.
... in order to escape criticism from parents, criticism from the administration, if you don't mark you are seen as not doing your duty effectively, so they expect every bit of work to be marked, including corrections. (Phiri, interview #2)

We are expected to mark daily class work and then homework again. ... The head of department, the headmaster too, expects you to mark the books. If he collects the books and finds work for the past few days has not been marked he says: “You are not doing your work.” (Mambowa, interview #2)

Teachers and parents remembered the routine from their own school days.

I don't know about the other ways because I have learned the same way. You know, the teachers used to mark everything. That's the only kind of feedback that I know. (Mabasa, interview #2)

Some of the parents, what they actually do is, if they get the time, to check the exercise books. They are not interested in seeing those totals. They want to see a red pen where a teacher did go through the exercise. (Mtisi, interview #2)

The children also expected the teachers to mark all their work.

They [the pupils] want their books to be marked. They do. You know the other time I gave them an exercise to do at home ... I'd given them some work and then I gave them some extra work. The next morning [I said] can you take your pencils, mark your books and when we are finished marking books they said: “Aren’t you coming around to give us that red tick?” I said “Ahh! but you’ve already marked, if there are any questions we can discuss ... [inaudible] ...” They want their books to be marked.(Mugedeza, interview #2)

It was very clear from my conversations with the mathematics teachers that administrators, parents, and children all expected exercises to be marked on a daily basis.

It was less clear to me, even after talking to the teachers, who set these expectations and for what reason.

And this about suggesting a daily exercise. ... I don’t think it’s a suggestion any longer because we are required to give them an exercise every day. That’s what they check when they come and see. Well, I give them a daily exercise. (Mabasa, interview #2)
I don’t know any other way. ... You are expected to mark ... it’s from the head of department maybe it’s from the EO or whatever, I don’t know who sets the standard. I don’t know whether it’s from the Ministry as such.  
(Mugedeza, interview #2)

I also asked the administrators about the marking routine. In response to my comments in Africa Report #2, Mr. Shiri observed:

On a lot of time being spent marking. My personal view is that this is as it should be. Little real “contact” is available. The only way the teachers can keep in touch with pupils, communicating and giving feedback is through the written work, by marking it, correcting and identifying problems and weaknesses and assisting pupils. In any case, few subjects offer oral examinations. The only way to keep them preparing is through written work. EOs, heads, parents, and even teachers and pupils have come to understand and accept this as the way things should be done.  
(Personal communication, 16/07/94, p.5)

In conversation, Mr. Mukoyi wondered how the pupil would know about his/her work if it was not marked (Field notes: 30/09/93, p.115).

I searched school documents for an official policy statement on marking. A circular from the Ministry (Midlands Region, 1987) stated: “Pupils should be set as much written work as possible. All written work is to be done in exercise books and subsequently marked (p. 2).” Another circular from the Ministry (Gweru, 1993) stated:

There are no oral examinations in mathematics. This means that pupils should be given plenty of written work to enable them to practice the skills and concepts they have learnt—as far as possible pupils should be given written work daily. ... Marking of written work should be prompt and always up to date and the exercise books quickly returned so as to provide quick and effective feedback to the pupils (p. 6).

The regional office set the expectation, then. Because large class sizes precluded individual contact during lessons, the written work helped to ensure that children were well-prepared for the examination. The departmental policy (11/05/93) also referred to written work:

Adequate written work should be given on a daily basis. Marking must not only be up to date, but also thorough with
constructive and encouraging comments made. Errors must be pointed out to enable pupils to do their corrections without difficulties (p. 2).

The Ministry expectations were reflected in school policy. However, the Ministry did not require written work on a daily basis—it should be given “as far as possible.” The goal was “plenty of written work.”

The HOD had explained to me at the beginning of term the departmental policy with regard to setting and marking fortnightly tests and exercises. He thought that it would be a good idea for the children to write common tests, sometimes set by other teachers.

So I just wanted that commonality so that everybody feels very much at home even if Mr. X who does not teach them gives them a test. (Phiri, interview #1)

Every second Friday, rather than giving the children a test, we assigned and collected an exercise on the week’s work which was also to be marked thoroughly and returned on Monday.

You know it is very difficult to be thorough in one’s marking every day of the week. Now there is a tendency, maybe, that one can tend to develop that type of marking which is not thorough throughout. ... We are not saying one should not be thorough in marking during the other days. No. All we are saying is to have a closer look this time. Try to have all the time this time so you mark and mark thoroughly. Try and stress common errors pupils’ are making so next Monday you give them the books, you quickly go through the exercise and point out the common errors they were making and by so doing you’ve actually helped the revision of that particular week. You’ve actually identified the problem areas as far as the topic is concerned. So this marking I think is going to help quite a lot. (Phiri, interview #1)

I marked the Friday tests and exercises thoroughly and it was time well spent. However, I found myself questioning the educational value of the common tests as well as the daily marking. Many of the pupils got such low marks that the tests provided little information about what they could do; they showed only what they could not do.

I wondered if the HOD had any concerns about the teachers’ professionalism. Had they not been setting and marking enough work?
There wasn’t any problem before. Everything was going smoothly. We are a fortunate department. We seem not to have any problems with the members of the department. They are doing their work very well. ... It’s not that people were not doing their work. ... It’s only that I wanted things done and done in a systematic way. A method that could easily be checked even with someone who is coming in who wanted to see these. I could easily point out, like I indicated earlier on, that I wanted things. I could explain when an official comes in, when the headmaster wants this, if someone wants to know what we are doing in the department we can simply give him the department policy and say this is exactly what we are doing. It is not that people are not doing their work. (Phiri, interview #1)

Documenting that the teachers and students were “doing their work” seemed to be more important than the teaching/learning process. It troubled me that teachers did not have more discretion to make professional judgements about what would facilitate learning. I thought that we could and should decide what to mark and when to mark. Although I could understand that untrained and beginning teachers needed to be given direction, my colleagues were trained, experienced, and committed. In my view, the marking routine limited their ability to practise their professionalism.

I learned from the interviews, however, that the teachers did not follow the marking routine just to meet Ministry expectations.

You may find the parent is keen enough to buy a textbook with the answers, but is the kid going to use it profitably or going to copy answers? I personally discourage the use of answer books. From my background, I actually don’t want pupils marking each other’s work. ... if you have few kids, you tend to do it. You are more effective. (Phiri, interview #2)

... because of the numbers these days, it makes the marking more tiresome, perhaps. The load is more. But with the kind of people that we have sometimes you will find that you cannot ask them to exchange books and start marking each other’s work. You might have problems there. (Mtisi, interview #2)

I have to mark everything I give them because some of these don’t even do their work. And you won’t even see whether they have done their work or not if you don’t. So ... I think you have to mark it, each and every exercise. ... if you don’t mark the kids won’t do their work. They don’t. They will just know that the teacher is not going to mark our work, she is not going to look at
it. We are always marking our own. So why bother? They will not do the work. They need that drive. I’m going to look at the work. I have to comment on the work. If it is poor, or if they haven’t finished their work, right, finish your work. You have to see them to see that the work is done. They need that drive. They’re kids. You know, they want to play. They don’t know what’s important. ... I do it because one, I am expected to do it, but paramount, okay, I want the kids to see that at least they’ve got some feedback. This is okay. This is not okay. That is the very most important thing. Otherwise, if it wasn’t something that I was expected to do, I would even mark it. There was no way I wasn’t going to mark it. (Mugedeza, interview #2)

The teachers marked not only because they were expected to but because they believed in the educational benefit. The children would not do the work unless it was marked and, in most classes, they could not be trusted to mark their own work. To the teachers, providing this feedback to students was an important part of the learning process.

The teachers handled the marking load in a variety of ways.

The teacher can devise methods on how he or she can go about it. You look at the work you are going to give. If you feel this concept is difficult to master and it requires a closer look on the part of the teacher when it comes to marking then you have to be a bit thorough on that aspect. Where it is a bit lighter, you feel ... because, well, percentage, where the pupils have a good background to that, then one can quickly look at the answer and go through. But here we’re saying they are actually doing the work; they are not cheating from an answer book or something. (Phiri, interview #2)

I prefer to choose the examples that I am going to give. In that case I will know that I will be able to mark the work that I had given out. Because there is no point in me giving a whole exercise when I know it is going to mean taking one-quarter of the night marking. ... Except with 2A I am marking every exercise that I give. They are fairly clever. They can mark some of their own work. Yes, I do some of the marking in class. (Mtisi, interview #2)

... because you end up, you mark during the lesson. You teach maybe twenty minutes then you, the other twenty minutes the kids will be ... [inaudible] ... going around and marking. You see, then you end up with little marking in the end because you have marked some of the books during the lesson. ... I end up
marking each class every day. ... No I don't [mark at night]. I don't. If I don't finish the marking in class then I take the books to the staff room and then mark through. (Mabasa, interview #2)

You just manage. Sometimes you have to carry books home. Sometimes you make sure that lunch time, free time, you are occupied. Make sure that you mark as much as possible in class. Helping the kids, then finish free time. (Mugedeza, interview #2)

The teachers had different coping strategies. In better classes books could be exchanged. Less work could be assigned. Easier concepts could be marked less thoroughly than difficult ones. Most teachers marked in class while the children were doing the work and in the staff room during lunch time and free periods. They did not do all this work just because it was expected of them; they did it because they felt it was in the pupils' interest.

However, the teachers' comments also validated my concern that the marking was not always effective.

... what it actually means is in the end the marking is not as thorough as it should be because people are just marking the answers without necessarily looking at the working sometimes. (Mtisi, interview #2)

If we are to help these kids, we've got to go through and point out the mistake, this is where you went wrong, you should have done it this way. But if you do that you won't finish. Individual treatment cannot be done. (Mambowa, interview #2)

I surely believe the marking is not as effective as teachers would want it to be. Because of the load—you are looking at not less than 200 pupils per teacher per day and you have to do the marking right through and the following day you are giving another exercise. (Phiri, interview #2)

They believed in the benefit of marking and were very conscientious about it. But with the numbers of students, it was not always meaningful.

Also, the marking routine meant that they had little class time to adapt instruction to the children or out-of-class time to prepare their lessons.

So, like here for Maths they say you have to give an exercise or two every day. ... You have to go through it [the content of the lesson] again and again. And then at the end you won't have
reached the stage where you can give an exercise. And then I think sometimes it's not strictly that you have to, while they want an exercise every day. ... It's okay. It's reasonable, but as I said some instances ... they don't have to stick to their, to have to give [an exercise] every, each and every day. (Mugedeza, interview #2)

Because we end up not doing some of those things like we minimise group work, we minimise using a lot of teaching aids because you want to teach and mark. I'm no longer very sure because I haven't tried the other methods like the whole lesson teaching without giving them feedback. I haven't tried that because I have been giving them work ever since I have started teaching. (Mabasa, interview #2)

Expectations about marking, then, were a significant influence on how teachers planned and organised their lessons.

**Classroom Discourse and Language of Instruction**

When we had class discussions with the pupils it became apparent that communicating with them was an even bigger problem than I thought. I became aware that many students did not know what to do in my classes. It troubled me that on consultation day some parents said that their child did not understand me in class. However, comments of the other teachers in the final interviews indicated that the problem was not just mine; it was general and complex.

It's really a problem. They find it difficult to understand certain concepts. (Mambowa, interview #2)

If you find some kids coming from grade 7 being unable to, in some cases, to write one simple English sentence, you hardly expect them to understand the maths that you expect because in any case anything in those textbooks is written in English. (Mtisi, interview #2)

In actual fact, it's a general thing. Language. They don't really understand English. ... You know I have home economics, foods and nutrition, you'd be surprised. They want to say something. They know, but they can't express it in English, good English. Like this other time. Somebody was saying: "Why do we have to keep our instant coffee in an airtight container? The reason was so that it doesn't harden, or it doesn't get lumps because of that moisture. They know what they want to say but they can't
express it in the correct English. What they were writing: “So that it doesn’t get ... [inaudible] ...” They know what they want to say. They have a problem with their English, these kids.
(Mugedeza, interview #2)

Yes, the English language is a problem. They don’t understand you at all. Especially when you are doing word problems. ... They don’t understand the language. I don’t think it’s just you. Your problem is that you don’t have the other language to explain.
(Mabasa, interview #2)

I asked the teachers if, or when, they used Shona. I was sensitive to my limitation; speaking Shona seemed to be an answer.

In some cases I do. But then, I try not to do it that much because you won’t find anything being asked in Shona. So if you do that most of the time you are encouraging people to think in Shona and try to translate that into English. In some cases, yes [it will help to get the concept across.] But I’ll give you an example. The word “equal.” Often it seems people use the word “same” for that. The angles are the same, whatever that means. The lines are the same. It would make sense if you say the two angles are equal. There is no doubt about what you are meaning there. But they don’t want to learn that word “equal.” They prefer the word “the same.” You see, it’s a result of trying to translate the Shona word into an English one. It’s “zvakafanana.” So, I mean, that’s the problem you might have if you try to do too much of those things in Shona. You don’t get the actual meaning.
(Mtisi, interview #2)

Yes, I sometimes use Shona because there are times when they don’t know what you are saying. (Mabasa, interview #2)

In most cases, I tend to use Shona to try to explain certain concepts. I do use Shona. Using simple language, English, some do not even understand what I am talking about so I tend to revert to using Shona. It’s not fair to use Shona, really. There are some Ndebele students who don’t even understand Shona. It’s a problem. (Mambowa, interview #2)

Teachers were reluctant to speak in Shona all the time for a number of reasons. They could not always convey the desired meaning in Shona. Some of our students spoke Ndebele as their first language. English, the language of instruction, was a colonial language but it is also a common language for both Shona and Ndebele people and an international language. The textbooks and
examinations were in English. Certainly, the problems surrounding language of instruction were complex and much larger than my personal problem with 1E and 3D.

Teaching Methods

From the initial interviews with the teachers I learned that they were not aware of the methodology statements in the current local syllabus.

I'm not very sure as to whether there was a complete shift from the previous one. (Phiri; interview #1)

I don't think [the HOD] has shown me that one yet. ... I haven't looked at the syllabus you are talking about, but I don't think there is going to be much difference from this international one, if anything, they might have left a few topics. (Mtisi; interview #1)

I haven't studied the international one. This is the local one? I wouldn't be able to compare them because I haven't studied the international one. (Mabasa, interview #1)

I'm sorry. I haven't really scrutinised, haven't looked at it carefully. (Mugedeza, interview #1)

In fact it's my first time to see this thing. It's my first time to see these suggestions. (Mambowa, interview #1)

Teachers usually prepare their schemes of work from the school syllabus and so may not have examined the original syllabus. The departmental policy (11/05/93) explicitly stated that whereas every teacher must be given a copy of the school syllabus they must only have access to the official syllabus. How could they implement the methodology statements if they were not even aware of their existence?

Group-work: Participation and Noise

Several of the teachers had indicated in the initial interviews that they used group work.

Group work also helps. ... I think they enjoy that more. ... When they are teaching each other I think they understand more. (Mabasa, interview #1)
But groupwork, yes, it’s okay because at least that is the time when some pupils are able to mix with the others and then they can give ideas. Some of them, are afraid to, to say out whatever they want to say when they are not in a group. They would rather say it as a group. So, at least when it is well-organised and you have time, like a double period. It’s quite helpful to the kids. (Mugedeza, interview #1)

... this [group work] I am doing. I find it quite interesting at times. Even enjoy it. Because you will find that some of our children are so shy. They do not want to talk. But if you are in a group like that, they enjoy, they talk in that group. So I have, nearly every week, I have got two lessons that I spend on my group discussion and group project work. We work problems together in their group exercise books. (Mambowa, interview #1)

The advantage was that whereas only a few children spoke out in the whole class, most would contribute in small group discussion.

In the initial interviews, the teachers had pointed out that implementing small group-work effectively required paying careful attention to management issues.

I think you will have to select the groups yourself. If you make them choose their own groups, I think you will end up with one group doing very well and others doing nothing. You can’t even help. (Mabasa, interview #1)

... again the number of pupils. ... It’s difficult to control such a group. ... You have to go to this, and maybe when you come from, go to the next one, these ones will be doing their own thing. ... Once they are large groups it won’t work because you have to touch those things. You have to use them. Each and every person has to contribute. So if they are a large group you end up with the bright ones doing most of the work for others. (Mugedeza, interview #1)

Because of my difficulties, I pursued these management issues further in the final interviews. I indicated that some students had complained about the fact that not all children participated.
You end up with the leader being the only one who is doing everything. ... I don’t think it’s possible with 46 kids. ... I don’t think it’s possible to have every kid doing the work. (Mabasa, interview #2)

It works for me in good classes like the A stream, 3A or 2A. It worked very well because the pupils are very cooperative and they know what they are doing, if you put them in groups and ask them to do something. It worked very well using geoboards. I didn’t have any problems. They actually enjoyed it. I was looking at dividing the shapes into triangles in order to come up with the sum total of internal angles in a polygon. It worked quite well, pupils trying, actually doing some other methods which I was not aware of, using two rubber bands, dividing the shapes into ... [inaudible] ... and the like. It works for above average pupils without any problems. (Phiri, interview #2)

Phiri found that pupils in his 2A class needed little direction because they understood what to do and cooperated well. On the other hand:

When it comes to below average students they may not know what to do so the involvement of the teacher there tends to be a bit increased in order to give them direction. You may even find yourself, if you’re not very careful, going back to the board and teaching rather than let them do what they feel is right. On the second aspect, guided discovery, if you ask, actually, questions, leading questions, leading to exactly what you want to finally achieve, maybe it will work for the below average group. (Phiri, interview #2)

Phiri found that the “below-average” students needed more guidance than the “good” classes. He commented further:

Again it boils down to skill on the part of the teacher. At times, I don’t want the group-leader to be secretary of the group. I want the writing part of it circulated among the members so that each and every body has a turn at least. You find if you give that work to the less able pupil in the group they tend to push him and if you are not careful you just give them your back and all of a sudden you come back to them and you find the able one has taken the book from him and is doing the writing. There is a tendency of the work being dominated by the bright ones. That’s the problem actually. (Phiri, interview #2)
Keeping the groups small did help to prevent the "bright" ones from dominating.

I think I benefited from your advice on group work, that the group shouldn't be too large. Because at times I was looking at groups of 8 to 10 pupils each and I tried to reduce the number to 5 but then the problem is you end up with so many groups, say 5, out of a class of 50 you end up with 10 groups. But I think it becomes more effective if you lead them into small groups because you end up with average pupils in some instances leading groups. Therefore, if they have chosen a leader they must be doing something, rather than being under somebody. So I find it a bit manageable, a group of 5. It's quite something. Actually 3 to 5 is quite acceptable, I think. ... I read the book. I didn't finish it. The areas I read, I got that type of information. (Phiri, interview #2)

What the teachers said corresponded with what the students had said about the inner workings of the groups. The solution to greater participation seemed to lie in structuring the groups carefully, keeping them small, and giving more guidance to less able classes so that they knew what to do. The large class sizes made it difficult to form small groups though, especially if the groups needed to use limited resources.

I had been somewhat surprised to learn from the class discussions that children in my classes were, at times, uncomfortable with the noise level in the class. I thought the children worked very well in groups and even though the classes were noisier at these times, I did not perceive this as a particular problem. The student feedback confirmed that students saw it differently. I explored the issue further with the teachers in the final interviews.

By choosing a leader, group leader there to monitor the noise and the like, I think it can be minimized ... [inaudible] ... I don't think it is much of a problem, if the teacher is around to minimize the noise. I think it's a matter of background here. Maybe they're used to learning quietly, they're actually passive participants. They are used to a teacher, maybe, in front of them and they are doing the listening. (Phiri, interview #2)

Perhaps one of the reasons the pupils might have felt strange, they might not have been used to you. Perhaps that is one of the reasons. Or they found your method of teaching a lot different from most of the teachers. That's why perhaps they might have behaved very strange. If you look at it, honestly, you will find that the teachers are not, most of the teachers here are not trying
all these methods that we are trying, we are talking about, the
groupwork, whatever. If you were to pass, if you were to move
from Room 1 up to Room 9 there you wouldn’t find a class
making noise. If that happens you find the door being opened
and someone trying to find out what they are supposed to be
doing. You see. So that’s why I am saying perhaps it was they
found it strange. But I wouldn’t go to the extent of saying that
they disliked it. (Mtisi, interview #2)

I had observed what I called a “culture of silence” in the school.

I think the kids are generally conscious of the noise because they
get beaten if they are found making noise. That is the only
reason why they are uncomfortable. ... I don’t know if this noise
is helpful because let’s say everyone is having their group work
and the whole school is noisy. I don’t think the headmaster
would be happy. (Mabasa, interview #2)

The teachers confirmed that students were expected to be quiet during
lessons.

On the other hand, most of the mathematics teachers thought noise
was a sign of constructive activity.

If it is a matter of complaining that the other groups are making
a lot of noise and that they cannot work, then what exactly were
they doing? Do they want to work quietly or what? To me, the
degree of noise. They may be excited and make a lot of noise
while they are not aware of it. The group that is making a lot of
noise may be making a lot of progress because they are excited
with their results. (Phiri, interview #2)

No, the kids are used to noise. ... I know other teachers are
against it, For example, the teacher next to you might say “You
are making a lot of noise.” They are expecting the children to
write a composition or whatever it is. ... Personally, I enjoy the
noise that they would be making. At least it is a sign there is
activity going on in the class. They are thinking ...
(Mambowa, interview #2)

You can’t rule out noise when it comes to group work. It has to
be noise which is constructive. They make noise, reasonable
noise, because they are excited. They are getting something. Like
what we were doing. We were all so excited but we were doing
something which was constructive [playing the isometry game
during the workshop]. But not too much, to disturb the next one.
From the excitement comes the result which is good for kids so no problem as long as it is not too much. (Mugedeza, interview #2)

Expectations regarding silent classrooms, of administrators and other teachers, and sometimes of the children themselves, could be a factor limiting cooperative activities.

Activities and Teaching Aids

Mabasa had indicated in the initial interview that she used practical activities when she could.

This is what we were taught at college. ... I still meet problems. We use those practical methods. Yes they understand. But when you ask them the same thing tomorrow you think they would recall that. But they don’t. Well, but the lesson will be interesting anyway because you understand each other during that lesson. ... I would improve on the practical side. At least when the kids are doing, I think they learn better by doing. (Mabasa; interview #1)

The other teachers said that it was not possible to implement many of the methodology statements in the syllabus because it would be too “time-consuming” as they had to “cover the syllabus.” In any case, they did not have the necessary resources.

They are fair demands as far as I am concerned but it’s the time. ... Time and the resources, especially money. (Mtisi, interview #1)

We haven’t got enough time, so some of these things are not practical. ... Sometimes group-work is not practical ... because it’s time-consuming. You would rather teach and then give them some work to do. ... because some of these aids they are time-consuming. ... You can use teaching aids like what you have. They are quite good aids. But the time to use them, that is the problem. (Mugedeza, interview #1)

Sometimes I find it’s very difficult to start from concrete things; like circumference, I should have started by trying to use different methods of measuring like the use of a string. But I couldn’t get the string so I just didn’t do the practical part of it ... and worse still, I found it time-consuming so I just went straight on to a different topic. ... It’s time-consuming, especially when you are expected to cover the syllabus. By the end of the week
you are expected to cover up to that stage. Now with practical work you won't complete what you have schemed. So that is the reason why we always leave the practical work.
(Mambowa, interview #1)

In the teachers' view, the suggestions were fair, but not feasible in the circumstances. They did not have the resources and they did not have the time.

I wondered about the expectation regarding "covering the syllabus." Who expected them to cover the syllabus?

The school obviously expects, I mean their main aim is to expect everyone to pass. (Mtisi, interview #1)

You are expected to make these kids pass, and, well, we may cover the syllabus but making these kids pass is a problem. ... The problem is if you don't cover the syllabus even the parents will start complaining. "Well, this teacher is not teaching. You just go there and play." Yet you want them to know something. So we have to cover the syllabus so that we don't have pressure from the administration, from the parents. The parents will end up complaining: "Yes, he didn't pass because she didn't even cover half the syllabus." (Mabasa, interview #1)

The administration of the school as well as the community expected teachers to cover the syllabus. The teachers were caught in a dilemma—if they slowed down, more children might learn, but if these children still did not pass, then that failure would be attributed to the teacher.

After the initial interviews I did not think that the teachers were likely to take time to use the resources that I had brought.

After finding which of these methods are practical is it going to change anything in the syllabus? After finding out there are some better ways of doing some of the things, will you be able to use those ways? (Mabasa, interview #1)

I felt acutely aware of the gap between curriculum developers and teachers—they live in different worlds.

In the course of the following two terms, Phiri and I used the resources most. However, in the final interviews, Mugedeza and Mabasa indicated that they had used them more than I thought. They had used the geometric shapes with the Form Ones, marbles and playing cards for teaching probability
to the Form Threes, and geoboards and mirrors for transformation geometry with the Form Fours.

Several comments in the final interviews give further insight into the difficulties teachers encountered in using the resources. I asked if they had found them to be useful.

In a way I would say they are very useful. The only problem is that maybe teachers tend to ... especially when exposed to new things. ... maybe we did not use them extensively, but we used them. (Phiri, interview #2)

Yes, I actually find some of it useful although I did not have a lot of time to try it because I was very busy and all that. ... It's a question of getting used to the stuff. The more you use it, perhaps the better you understand it, and perhaps may be able to appreciate its effectiveness. ... I am always interrupted, interrupted in my actual lessons. ... That actually puts a strain on my planning, the actual planning where then I would need to examine the aids that I would need for a particular lesson and all that. (Mtisi, interview #2)

The marbles, the playing cards for probability. Those were very helpful. I used them with my Form Threes last year. I think they enjoyed the lessons and well, I was using those aids simultaneously with writing the things on the board so I think I didn’t have any problems with that. Unlike when I was doing the transformation geometry when I couldn’t use the geoboard and write at the same time. So with probability it was very easy and I think the aids helped. (Mabasa, interview #2)

They are very useful. The problem was the time maybe to use them. And then some of these things we didn’t, until after the seminar we weren’t exposed as to how to use them. So we wouldn’t just go to and then start using them. Or maybe we should have asked you how we would use them. The time factor, we didn’t have the time to sit down and find out what methods we could use, how we could use those aids. With time table jammed like this you can’t just go to the cupboard, take something. It needs careful planning. ... When you’re learning new ideas, some of these things you never think about, just think about finishing the syllabus, never think about introducing a new thing, starting from concrete situations. You just want them to know the facts, what they should know. Finish the syllabus and that’s all. (Mugedeza, interview #2)
The major factors which limited the extent to which the teachers used the resources, then, were a lack of awareness as to how they could be used effectively and the extra preparation time required to incorporate new ideas into their planning. The latter was particularly true for Mtisi, who, as senior master, was often interrupted in his class and in his office.

I wondered whether the resources would have been used more if they had been more accessible. We kept them locked in a cupboard in one of the classrooms.

It is one of the factors. You had to look for Phiri you see. He has the key. We are not in charge. You are not in control. At least there has to be somebody but at times you think: “Ahh! I’ve got to go for those things.” You have to run around like what we do for books, if we want exercise books. I mean it becomes very difficult and then at the end you say: “Ahh, let’s skip it. I’ll see next time.” Then there’s always the next time but it never comes true. (Mugedeza, interview #2)

Most of the teaching aids were unavailable or expensive in Zimbabwe.

We can’t just display them because we will end up with nothing. People just take. ... And some of the teachers were asking me “Why don’t you just give us one packet of cards?” So I said “We need them here.” And they were asking me for the dice. “My daughter lost a die for snakes and ladders.” So I think if we display them we just end up losing them. (Mabasa, interview #2)

The children were extremely good about returning the equipment. But we lost a calculator on consultation day and we found that other teachers wanted to borrow the calculators for their own use, especially when marks were due. Although keeping them under lock and key may have limited their use, if we had not done so, we may have found that they went missing over time.

Mabasa raised another issue.

Yes, I think they are very useful. A lot of the aids you brought are very useful. But I discovered when I was using those geoboards, those small ones. ... You do it on the geoboards but the kids cannot transfer it to their graph books. ... They enjoy using those geoboards. You are explaining, yes, stretch this to this, using that. Then when you come to the graph book you have to go back again and start from the beginning because they didn’t understand when you were doing the practical work. ... I mean they understand that part but they cannot put it in writing.
... You have to start from the beginning. You have to. I say, you make your square on the geoboard, then you cannot just go ahead and give them an exercise. You have to do it on your graph, then show them how to do it theoretically now and I think ... yes, it takes more time. (Mabasa, interview #2)

Mabasa found the pupils could not transfer directly from using geoboards to using graph paper. The trigonometry question on the mid-year examination was very similar to the flagpole activity Phiri and I had done with 3B, 3D, and 3E. I marked papers for all the Form Threes and noted that students in 3A did better on this question even though they had not done the practical activity. Other than the students’ own comments, there was little evidence that they learned from the activities. It seemed that without taking more time to make connections for students the activities could not help them with their textbook exercises or translate into performance on traditional assessments.

The Mathematics Club: Different Perspectives

In the final interviews, Phiri and I reflected on the experience of the mathematics club. The syllabus methodology suggested non-routine problem solving, activity-based learning, and project work. I thought that if there was no time to do these things in the classroom, why not in the mathematics club? It became apparent in the interview that Phiri had a different vision of the club.

... we are used to clubs in the form of sports where they are doing music, they are singing, they are playing darts, they are playing chess, they are playing whatever, games. The teacher is not dominating. Even if you are not there they can do it themselves. That's why the cards were so popular in our maths club. They are used to playing crazy eights at home. They wanted to play that. So they want that type of atmosphere where they do what they want. Now the problem is, if they are exposed to equipment like you brought, they cannot make sense out of it so a bit of some direction should be given as to how to use the equipment. (Phiri, interview #2)

Phiri felt the club should be very pupil-centred and not related to the syllabus.

... pupils must feel they are a bit removed from the classroom. They are doing things that they want to do, things like games. ... [in] the history club you may find the teacher actually teaching
the pupils. To me, you are not exposing pupils to the club type of material. I think it must be dominated by the pupils. Now, how to make them dominate it is another story. Because if they are not used to a maths club one has to come in and give them direction. (Phiri, interview #2)

Both our views differed from that expressed by many of the students who attended the club. They had expected the mathematics club to provide extra help in preparation for the examinations (like the history club).

Phiri also felt that pupils from different forms should be involved in the same activities. But this could be difficult to do.

The problem with doing projects you may find you have pupils across the board—Form Ones, Form Twos, Form Threes, Form Fours. Now, if you propose a project on trigonometry then the Form Four, Form Three chap is going to benefit, the Form Ones are left out. You have to go to their level. One has to be very careful. That’s the problem. If you look at crazy eights using cards, that game is popular. The Form Ones may play with the Form Four pupil. That doesn’t make any difference to them. But when it comes to areas of concern from the syllabus then that discrimination has to be there. That’s the problem. It now sort of ceases to be a club, the moment it centres on the syllabus. What I am saying is, the activity should be popular among all the pupils, irrespective of their level. (Phiri, interview #2)

We did agree that part of the reason students lost interest was because we did not give adequate direction. The mathematics club had not been “technically sound” in that we had not provided the teacher direction to support an alternative model to what the students expected.

In summary, although children enjoyed the group activities and working with the teaching aids and although the teachers thought that there were good pedagogical reasons for using these methods, they still felt constrained. They needed time to use the methods effectively—time for lesson preparation and time for consolidation of the concepts—and this was time they did not have. More and more, I thought the problems we were facing in the school were not going to be solved by altering our teaching methods.
Curriculum: Core Syllabus and Alternative Syllabus

Changes in assessment and curriculum seemed more needed than changes in teaching method. In the final interviews I asked the teachers: “Why do the children do so poorly on the tests we give them?” They responded that the children were used to multiple choice tests from grade seven, and that they “forgot” because they did not practise.

Lack of practice. They don’t practise when they are at home. They just leave it, ... [they’ve] forgotten, so how can they pass the test?
(Mugedeza, interview #2)

But why did the pupils “forget” so easily? Was the only solution more practice? In the final interviews I asked the teachers what they thought about Mr. Mukoyi’s suggestion that we (all departments) give tests which were more in line with the ability of a particular class. Mr. Mukoyi had said in response to my expressed concern in Africa Report #2:

The idea of setting separate tests for 2A versus the other slow classes can be further discussed in the department. I will not object if it is recommended and is reflected in the teaching pace as for work schemed for different groups. I have no answer to the problem of low marks in 2B to 2E except that the logical thing would be to make the tests useful by adapting them to the pupils’ level of performance in the chapters covered. Better marks will certainly arouse interest—the opposite will only frustrate the kids—tests will lose meaning and value thereafter. Streaming strategies are continually being reviewed so that there is one good group and the rest are mixed alphabetically to allow mixed ability and remove negative stigma of being in 1E or 2E.
(Response to Africa Reports, 26/11/93)

The headmaster’s suggestions about testing and streaming had been discussed at our end of year staff meeting; the teachers’ reactions had been mixed. In our conversation, Mr. Mtisi endorsed the idea of adapting tests to the students’ performance.

I have some problems in that area also because in some cases, like I am teaching 2A and 2E. I don’t want to give the two classes the same test because what is meaningful to 2A is not necessarily good for 2E. ... after completing a certain chapter or so, I want to give a test to make sure that they have understood what I was teaching. ... So in some cases it might have nothing to do with
ZJC or O-level standards. I am just trying to find out if they have understood what I have done. (Mtisi, interview #2)

The other teachers were skeptical, however.

Motivation. We shouldn't do that. ... sometimes you should just to motivate those in 4E. Give them something which is a little bit easier, one time or the other. ... Since they are going to write these exams you can't be giving them all the easy things all the time. Because what are they going to do when they encounter the exam? But for motivation, maybe give them easy problems now and again. (Mugedeza, interview #2)

We can make the test a lower standard but that won't help them. In the end they want to pass their JCs. (Mabasa, interview #2)

In giving a test we've got to look at the bright ones, the average and the very poor ones in compiling your test. Bright ones, ZJC standard; for the slow learners, just simple sums so at least they get something. Not really different, one, within that one test, the three groups of concepts, standards that are going to be tested, the very good ones, the average and the very slow. I won't mark them differently. Obviously [the poor ones] will get low marks. (Mambowa, interview #2)

Only Mtisi concurred with the headmaster and me that tests were most useful when they were designed by the teacher of a particular class to find out what pupils in that class knew. The other teachers thought the tests had to reflect ZJC or O-level standard—the "poor" ones were destined to get low marks.

But these children, the majority in our school, were being left behind in the rush to "cover the syllabus" and were not learning very much. I thought we could do more to help them learn, especially as the majority seemed willing. Students had responded positively to both the extra lessons and the remedial lessons.

It was a good idea but we didn't have the time to teach those kids. They were enjoying it. They were [glad to come]. Only one was a problem. Otherwise, it was a good idea. It is a good idea. But the time. I think what we need is somebody who is a specialist for that thing, a teacher meant to be a remedial teacher, nothing else. ... That was my free period. I needed that time to mark; I needed that time to plan my work. (Mugedeza, interview #2)
Maybe if we took time to teach the pupils they would not “forget” so easily. But the teachers were required to take the remedial lessons in their free periods and we gave the extra lessons voluntarily after regular classes. This was not an ideal or sustainable solution to the problem of limited time.

A core school syllabus which emphasised some concepts and treated others in less depth seemed to be a possible solution to the problem of limited time. At least some children would probably learn more. It was even possible more would pass. Phiri and I had discussed with the education officer the possibility of designing a core syllabus for the school. The EO had stressed that whatever we did should be a combined, consultative effort and that it should be documented. When we brought the matter up at a subsequent department meeting the other teachers supported the idea. In the final interviews I asked “What happened to the core syllabus?”

It looks like we had a problem in trying to sit down and get something written like what the education officer wanted. In the end, the teachers just suggested we should look at the type of class we are teaching. You can scale down the work on your own for that particular class other than have something written like that—leave out some such demanding topics like linear programming, like statistics, cumulative frequency and the like, the more challenging aspect. Leave that out and concentrate on the lighter aspects so at least they get something on the examination. So we actually didn’t sit down to draft one. (Phiri, interview #2)

I remember in one of our meetings we discussed that and we ended up saying, well, we cannot rewrite the syllabus. What we do is, we teach, let’s say we are teaching transformation geometry. When you are teaching the slow kids, maybe you just teach the rotation, reflection, and translation. You ignore the difficult things like shearing and stretching. ... what we agreed on. But I don’t think we are doing it. ... I think we avoided writing another syllabus. (Mabasa, interview #2)

The core syllabus died because writing another syllabus was more work. The teachers had agreed instead to adjust the syllabus for each particular class they taught.

The teachers also felt that preparing a core syllabus should be primarily the responsibility of the EO and the HOD.
The teachers were waiting for the head of department to take the lead. Since that meeting, nothing happened, no doubt about it. ... What I am suggesting is that if the EO and HOD could make that core syllabus where the bright ones, A, 4B, concentrate on the present syllabus those—you are sure they might pass. Other classes concentrate on basics only, simple basics only. I think that would be better. The HOD expects us to finish the syllabus. If we had the special syllabus for slow learners who are going to concentrate on concepts, it would be better. I would support that. Provided the aim of teaching maths is not to pass the Cambridge exam. (Mambowa, interview #2)

Although Mr. Mambowa supported the idea of a core syllabus, he saw it as an alternative to O-level. Mr. Phiri also commented that teaching a core would be “teaching for life” rather than the examination.

Mr. Mtisi, however, thought a core school syllabus could help some students pass.

Mr. Phiri actually went as far as talking to the EO about it and asked him to perhaps put it in writing. But I don’t know whether he, we managed to write anything. ... Because if we had done that, at least this year we might have had something to start with. ... It might even help some of these pupils get a C in maths. If you look at the way the marking is done, because they are not looking for a very thorough understanding of anything in particular, but a simple understanding and application of the ideas that the pupils are supposed to have been taught would be enough. But from the textbook that we use, some of the exercises there are very difficult. ... You are not helping anybody. ... I am trying to do that [assign only some of the exercises] with 2E. I don’t know how I am going to fare. But I think it will work. (Mtisi, interview #2)

Mr. Mtisi had adjusted his instruction for his 2E class by limiting the difficulty of the exercises he assigned. Mrs. Mugedeza was apprehensive, though.

Touching all the concepts but not in depth. ... It's okay. But I don’t know whether ... If somebody as an education officer comes and sees that maybe this is very shallow, they haven’t gone into the right depth, deep down. What will he say about me and my teaching? It has to be something which is official. (Mugedeza, interview #2)
Although most of the teachers saw value in a core approach they were hesitant to implement unless it had “official” status. As with the marking, it seemed to me that teachers’ perceptions as to what was expected of them limited what they were able to do to solve problems.

In the final interviews I asked if parents of the children at Kwelo were likely to support the changes we had discussed at the staff meeting.

It depends on the type of the parent. At times it is pointless explaining the changes to them. Because after all they are not interested in what is happening in the school. All they want is a full certificate at the end of the day. ... If you do that do you think it’s going to pass my kid? If the kid is going to benefit from that by coming up with five or more subjects then that’s super! The problem is as long as it gives their kid a job after O-level, they will support it. But if the industry will look down upon that syllabus you are in trouble, you are not teaching, you are not doing any service to them. (Phiri, interview #2)

I think the parents are only interested in their kids passing the exams. So I don’t know if they are interested in the changes we are making. All they need is the end result. ... because most of the parents send their kids to school so that they can learn and then get jobs, so that they can support the family. I think the job is what they want. If the kids go to school and get something less than O-level and they don’t get a job, I don’t think the parents will be happy. But if you can find something so that when that test or that exam then they get some kind of a job I think the parents will be happy. But if it means they are going to be unemployed ... (Mabasa, interview #2)

Parents tended to leave educational decisions to the school.

I mean honestly if our parents did bother to try to understand some of the subjects offered at a particular school, most would have simply advocated for the banning of this O-level stuff a long time ago. They just leave it to the school. (Mtisi, interview #2)

We then talked about an alternative to the O-level syllabus.

The reality was that only about twenty percent of the students in the country were going to pass the O-level examination. Any increase in the pass rate at Kwelo was going to be at best marginal. The parents’ expectations for their children were not realistic.
If you look at what is happening today there are lots and lots of Form Fours who are roaming the streets with a full five O-levels including English, mathematics and science. But they can’t get a job. Now they are failing to see the value of education. We grew up in a set-up whereby passing O-level was a passport to getting a job. Now that is irrelevant. It is one contributory factor making the whole thing a bit difficult for pupils to understand because they will tell you I have a brother with 10 subjects and not working. So why should I worry? (Phiri, interview #2)

This type of syllabus is for only about 12%, only about 12% of our students can do this type of syllabus. For the rest, it’s just a waste of time. (Mambowa, interview #1)

I think, looking at the O-level, the Cambridge thing, the exams, I think their standard is very high because of the type of kids that we have. It’s quite high. They don’t pass. It doesn’t mean they don’t know anything. (Mugedeza, interview #1)

Given that the children were not passing O-level and that there were no jobs, even for those with good passes at O-level, would the parents support an alternative syllabus?

It’s a difficult question. Some might and some might not. As long as they are assured that whatever that curriculum, that exam the kids are going to write is going to get them a job then I don’t think they are going to say no. But if it is just any other certificate where you just say you passed but you don’t secure a job. As long as they are assured that it is also going to be taken as one of the requirements of getting a job. Because all they want is for their kid to have a bright future. So if it is just any other certificate which is going to be kept at home and it doesn’t help you anyway, why bother? (Mugedeza, interview #2)

Even if you come up with an alternative syllabus then they will pass it. And if they do, what next? Then they will start questioning the importance of that subject. They know, for instance, that Maths is a difficult subject, whoever passes it must be jacked-up. That is the conclusion in the society. Now you water it down, all of them come up with As. And industry says no to the syllabus. Like what is happening in science. At GTC, there was an advert at one time they wanted more teachers in the science department, they said: no core science. Now what does that mean? It is the same education system which teaches the core science and it is the same education system which says we don’t want it. ... That’s the dilemma we have here. You water it down, the syllabus, and the next day the same authorities view
it with suspicion. They don’t have enough information, they don’t have enough concepts about the subject. Then it is pointless watering it down. (Phiri, interview #2)

The teachers saw little point in developing an alternative syllabus unless it was going to be recognised by employers. They knew that the community at large was reluctant to accept anything other than O-level as a credential for employment or further study.

I asked the teachers if they had any advice for the national panel in their deliberations about curriculum.

I would advise them to reduce the topics we are teaching, then, so that we have more time to teach the little. Maybe the kids could improve. Like what they did at JC they really reduced the topics. Well, I don’t know if it’s helping but I think it’s helpful. (Mabasa, interview #2)

They must specify that this one [O-level] is aimed at a certain percentage of the population. And perhaps state standards. You expect a person with passes in grade seven. And the other one must be suitable for the rest of the people. And then I would suggest that they should not put a time limit on the date for writing the exam so that the school can be given the leeway to determine which pupils are going to write after the four years and which ones can proceed to write after five years or so. The parents know. The nation knows. The politicians as well. If that happens, at least it reduces the pressure on the teachers. They might take their time and teach effectively. (Mtisi, interview #2)

If “there were more time to teach the little” then teachers “might take their time and teach more effectively.”

In summary, except for Mtisi, the teachers viewed assessment differently than I did. They were very conscientious and professional but were reluctant to vary the established routine with regard to assessment, teaching methods, or curriculum. This was not surprising, given expectations from administration, community, and children about examination success. Yet the majority of our children were not going to be successful on the examination. This reality meant that as educators we had to examine the feasibility of an alternative, possibly core, syllabus.

But any changes in curriculum from the Ministry were in the future. What could we do to address the problems now? The following chapter
discusses my exploration of in-service for mathematics teachers in the region and the workshop we organised for mathematics teachers from our cluster of schools. The cluster workshop was an attempt to address the teachers’ concerns about students, curriculum, and assessment in a broader forum as well as to encourage a greater variety of teaching methods.
display of teaching aids at workshop
"the display showed how they could be consolidated into lessons" (p.154)

geoboards on display at workshop
"a very good variety of media were used and covered most of the syllabus topics" (p.154)
another of the cluster schools
"we all have problems and we need to solve them together" (p.158)

local firm making graphboards
"graphboards ... went to each school" (p.158)
Chapter Eight

In-service for Mathematics Teachers in the Region and the Cluster Workshop

Fullan (1991) argues that most in-service has little impact on classroom practice. In 1984, I had wondered what effect the CTF/ZIMTA short courses would have on the teachers’ schools; in 1993, I was questioning the effectiveness of the school-based in-service model which I was trying to implement at Kwelo. This chapter addresses the question: How can teachers in Zimbabwe be helped to promote effective educational change? The Southern African context is very different from that in which most of the research on educational change and teacher development has been done. I had based my model on that research, choosing what I judged to be generic. Now I wondered: what else was happening in the region regarding professional development of mathematics teachers, and what could be learned from it? The chapter briefly reports on my participation in two other in-service projects for mathematics teachers in the region, as well as a workshop on remedial teaching which Phiri and I attended for HODs of English and mathematics in the Gweru urban region, and summarises what I learned from these experiences.

Most important, the chapter also describes and evaluates the workshop we held at Kwelo for mathematics teachers of the schools in our cluster on the 3rd and 4th of February, 1994 towards the end of my stay at the school. WUSC had been working with the Ministry to promote the cluster self-help concept among headmasters; I had not been aware of this Ministry initiative when I had formulated my model of professional development. The cluster workshop grew out of discussions between and among Phiri, Shiri, and me during the course of my project. My contribution was influenced by the other experiences described in the chapter.

The first part of the chapter is based on my field notes, and documents from the projects I visited. The field notes recorded my activities during the school breaks, including conversations I had with other educators. During the August break of 1993, I participated in an in-service project for primary teachers at the University of Zimbabwe (UZim) and visited another project at the University of Malawi for junior secondary teachers. At both projects I chatted with teacher participants in order to find out how the teacher participants viewed these in-service opportunities.
The second part of the chapter is based primarily on a report written by Mr. Shiri and me about our cluster workshop. This report circulated at the regional office of the Ministry and copies were provided to WUSC and to head office in Harare. The original report contained a summary of the proceedings and of written evaluations. The proceedings were based on detailed notes I had taken during the workshop sessions. In the report, participants' comments about different aspects of the workshop were followed by our own observations and analysis. The report, along with documents collected from other projects, was filed with my field notes.

In-service Projects for Mathematics Teachers in the Region

Like my project, both projects I visited encouraged teachers to use methods which promoted more active learning and better conceptual understanding, provided resources to schools, and tried to support teachers in their work at school. The projects differed in that they were not school-based; rather, they combined workshops during school breaks at the university with school visits from project personnel during term. Also, they focused on science as well as mathematics teaching and the teachers were not as well qualified as my colleagues at Kwelo. The projects were initiated by the universities, not the Ministries, but the UZim project tried to involve Ministry representatives and selected the schools from Ministry clusters.

The Malawi Mathematics and Science Teaching Improvement Project (MAMSTIP) was focused primarily on content upgrading. It provided equipment and supplies to teachers' schools, and, along with a variety of other activities, supported the writing of curriculum materials by individual teachers (MAMSTIP: Progress Report No. 7 (draft); 27/09/93).

MAMSTIP was one of a series of projects sponsored by the Free University of Amsterdam (FUA) in Southern Africa (Botswana, Lesotho, Malawi, Namibia, Swaziland, Zimbabwe) over the previous fourteen years. It was the FUA report about science and mathematics teaching in the region which had motivated me to initiate my project. One of the principal authors of the report, Robb Merkus, was the coordinator of MAMSTIP. He felt there was an urgent need to establish parameters for good in-service training in the region. In his experience, the context differed in a number of ways from the UK and USA, where most of the research on educational change and teacher development has been done. First, teachers in the target groups were often
unqualified or underqualified; large salary differences motivated them to seek increased credentials. Second, the highly centralised educational systems limited the extent to which teachers could apply any new insights about teaching and learning which they gained from in-service. Third, because they tended to be organised top-down, Ministry programs did not always take teachers’ wishes into account. He thought programs should be more flexible and seek teachers’ opinions. Fourth, relations between universities and Ministries of Education were sometimes reserved; there was a need to seek better cooperation. Lastly, he thought that school-focused activities other than in-service training of teachers had significant potential to improve learning (Merkus, 1991).

The UZim research team consisted of mathematics and science lecturers in the Department of Curriculum Studies at the university and personnel from the Curriculum Development Unit. They wanted to develop and document classroom practices which were effective in improving students’ problem-solving strategies in both science and mathematics. Teachers and lecturers at primary teachers’ colleges tried to implement problem-solving methods while teaching the existing syllabus content in their normal classroom settings. One of the objectives of the workshop I attended was to explore possible teacher support systems.

Comments from teachers at the UZim workshop during large and small group discussions resonated with my own experience at Kwelo. There were the obvious difficulties: large class sizes, insufficient resource materials to keep groups small, and the need to finish a certain amount of content each term in preparation for the examination. In addition, it was difficult to work in English. Lesson time spent on required written work left little time for different approaches; marking time limited preparation time. One teacher commented: “It isn’t always necessary to write something.” My question: “Why do EOs require these things?” generated a heated discussion. “We can’t do it all!” “Everybody is watching you.” Again, it seemed to me that it was not so much the teachers or pupils who were “resistant” to change but the system itself (Field notes: 12/08/93; p. 79).

Through my involvement in the university projects, I learned more about teachers’ motivation to participate in them. In Malawi,

while we were waiting for the tire to be fixed I got a chance to talk to some of the teachers about the project. They thought it
was "manna from heaven." They didn’t think they would get a chance to go back to university after their DipEd and, as an incentive, the best from this two year in-service program would be given the opportunity to complete a BEd. This would give them more money. (Field notes: 01/09/93; p. 91)

It was difficult for teachers, like others, to make ends meet. At UZim, teachers who were selected to stay an extra day for a writers' workshop had been promised they would be paid for this.

Teachers are upset, talking amongst themselves, before lunch. At pay-out they were only given transport, not the fee they were promised. They have come at no small inconvenience to themselves and are disgruntled. [The project director] had to come and explain. He said it [the fee] would be sent later as it was desired that the teachers make corrections and improve the material [first]. ... As one teacher explained to me, though, people could have been with their families and some women were planning to go to South Africa and would have made about $600 by selling something at three times [the value in Zimbabwe]. (Field notes: 12/08/93; p. 79)

In the end, they got $30 each, which was not significant when balanced against the personal costs involved in attending the workshop. Most had families and other commitments; often the latter were related to economic survival. As some explained to me, though, they just wanted recognition for their effort and commitment; they had already made the decision to come. Despite the hassle about the money, money did not seem to be an important motivation for these teachers. Rather, they wanted to improve their practice. For example, I talked to a young man in the lunch line-up one day at UZim.

He said he was learning a lot from the workshops and was trying to put what he learned into practice. The pupils were doing better and his job was "easier." He said the pupils enjoyed the lessons and were getting better marks. His job was easier because it was more interesting. This was the first in-service he had done. He thought the Ministry could do more in-service; it was just a question of allocation of resources and priorities. (Field notes: 09/08/93; p. 72)

At UZim I also sat in with a group whose task was to formulate a statement of the aims and objectives of the project. This was to be shared with other, newer participants. They wrote:

148
Teachers do not accord pupils a chance to ask questions. Probably it's because they want to cover the syllabus, or, they want to go through what they have planned for the day or the week. ... From our own experience we have discovered that pupils are not empty vessels, pupils learn better by manipulation [of laboratory equipment and teaching aids], pupils are more interested, questioning helps the teacher to know what the pupils' understand or not, questions posed by the teacher help the teacher to direct pupils' thinking. (Field notes: 10/08/93, p. 75)

They told me that they had become convinced of the merit of the problem-solving approach because of the responses of their own pupils. Although financial gain was certainly an incentive, the teachers I talked to wanted to participate in these projects primarily because they felt that their pupils were benefiting from it.

During the holiday periods, as well as talking with people at the university, I had a number of conversations with mathematics educators in the Ministry, including the mathematics EO for Harare region (a personal friend and project leader of the CTF/ZIMTA course) and a mathematics EO from the Curriculum Development Unit (CDU). I learned that the Ministry had been concentrating on organising in-service for headmasters and HODS, partly because the number of teachers was so great. Regional workshops run in cooperation with CDU usually concentrated on examinations and interpreting the syllabus and did not address methodology issues. The EO from CDU observed that teachers preferred having information presented to them at workshops; they did not take it very seriously when they were involved in activities themselves. (Field notes: 12/01/96; p.190)

Another experience which influenced my thoughts about in-service was a workshop for HODs of English and mathematics organised by the regional office which Phiri and I had attended in June. Staff from the Special Psychological Services (SPS) had instructed the HODs to identify a remedial group (Form One pupils who were weak in English or mathematics but not both) using tests provided by SPS and to provide an extra two hours per week of remedial instruction to this group. When the HODs voiced their concerns: "I am going to have to ask an already very busy teacher ...," we were told: "It's a question of implementing policy, not what you want. ... The ladies [from Special Psychological Services] are behind schedule." We left feeling
frustrated even though we all cared about addressing the problem. The “ladies” had explained earlier: “We are trying to run away from these labels. At the end of the day, everyone can get some education. ... Can we do something more with the children in front of us?” At the time, I was struck by a need for discussion among participants even if the administrators were well aware of the difficulties. We had come from our respective schools and had had little opportunity to talk to one another. (Field notes: 15/06/96; p. 26)

In summary, I learned a number of things from these experiences and discussions which influenced me in the planning of our own workshop. First, teachers valued the opportunity to participate and were willing to try to change their practice if they could be sure it helped the children. Second, when workshops are held during school vacations, teachers must choose between professional development and important commitments in their personal lives. Administrators, curriculum developers, and university and college lecturers faced the same choices, so it can be difficult to get local expertise to participate. Third, Ministry involvement was essential for effective implementation, but the top-down approach of Ministries often made it difficult to address concerns of teachers. Last, as the teachers at the UZim workshop had pointed out, methods had to be implemented well (be technically sound) to get a positive response from pupils. This must also apply to teachers. I wanted to involve teachers in a meaningful activity at our workshop to prove or disprove the observation that teachers did not take such things seriously. I was becoming increasingly convinced, though, that supporting teachers in effective change was not simply a matter of encouraging them to teach differently.

The Cluster Workshop

Although the literature attributed failure in mathematics partially to ineffective teaching styles, I was finding that teaching as the syllabus suggested did little to address the problems teachers faced daily. Nor did providing additional teaching resources appreciably affect how teachers taught. While the resources helped children learn, they did not address the larger curriculum and assessment issues. The cluster workshop grew out of conversations between and among Mr. Shiri, Mr. Phiri and me during the course of my project. The intent of the workshop was to explore these matters further, with more teachers, within the framework of the Ministry’s cluster
concept. The idea behind the clusters was that schools sharing similar concerns could help each other. The workshop would model what schools might do to support each other in educational improvement. Both the Ministry and WUSC were very supportive of our effort because they had been working together to promote the cluster concept with headmasters.

Objectives and Organisation

One of our objectives, then, was to bring mathematics teachers together in order to promote the cluster concept and to share concerns and possible solutions to common problems. We also wanted to promote dialogue between secondary school teachers and teachers from the feeder primary schools. The target group was all mathematics teachers from the five secondary schools of the cluster as well as representatives from the feeder primary schools. Five student teachers who were at Kwelo at the time also attended. Resource persons were drawn from the schools, the two teachers' colleges (primary and secondary), and the regional office. There were two lecturers from GTC and one lecturer from Mkoba Teachers' College (MTC), along with the senior remedial tutor from Special Psychological Services of the regional office of the Ministry. Other objectives were to discuss teaching methods, to provide some mathematics teaching aids to the teachers' schools, and to establish a mathematics teaching resource centre.

Originally, we were going to apply for Ministry funding and, as the Ministry was trying to encourage local initiative within the cluster concept, we thought the impetus for the workshop should come from the schools. In discussions at school, Phiri and I found that teachers were more used to receiving directives from the Ministry than making suggestions. In fact, we used WUSC funding, because we could get it quicker and because my presence in the school as a WUSC associate provided a reason for focusing on our particular cluster. If the workshop was successful then Ministry funding could be accessed to do similar activities with other groups of schools.

The style of organisation that evolved was a combination of top-down and bottom-up approaches. Mr. Shiri approached the Deputy Regional Director (DRD) and then, with his support, visited each of the five secondary schools and discussed the proposed workshop with the headmasters. The headmasters were all supportive and cooperative. Heads of departments then met with Mr. Shiri, myself, and a lecturer from GTC (my former colleague,
now doing a masters' degree at the University of Zimbabwe) and we discussed
the rest of the details, including the programme and resource persons. Kwelo
was chosen as the most suitable venue and invitations were sent to all
resource persons and participants. The whole school mobilised to support us
when it was chosen as the venue.

My field notes documented the importance of administrative support
and the role of the EO and HODs, who did most of the organisation.

The HODs were keen about the whole thing (this is the first
they’re hearing about it, except for Phiri) and were very
constructive. I really like this kind of meeting where things are
tossed around until consensus is reached. I must admit
(however reluctantly) that I’m seeing advantages to the
administrative structures, everything seems to be falling into
place and people accept the delegation of responsibility and the
need to inform others. ... Anyway it was great. They were great.
We’re going to meet again at Kwelo on Wednesday afternoon.
(Field notes: 20/01/94; p. 212)

On the way home Phiri said he had discussed the workshop with
Mugedeza and Tanyanyiwa. They were not too keen about the
demonstration lessons but relaxed when they knew it wouldn’t
be them. Otherwise they were okay about it. Mugedeza said
something like: after all, we suggested some of those things.
(Field notes: 25/01/94; p. 216)

It’s quite amazing how it’s coming together. That support from
above is critical. ... I think it’s partly/mostly that they can see that
Shiri and the powers that be are supporting this. I suppose I may
have established credibility too; I don’t know. But I think the
former is a very important factor. WUSC phoned today. ... Head
office talked to Miriam and requested a report on the workshop.
... Phiri mentioned on the way to the bus stop, after our
conversation with Mr. Mukoyi, that he was reluctant to take
more responsibility because no one would have listened to him
or taken him seriously. (Field notes: 01/02/94; p. 226)

My role was mainly to act as “go-fer.” I had more time than the others
as I was no longer teaching. I really enjoyed the collaborative spirit, in
contrast to the isolation I had felt in the classroom.
Teaching Methods and Teaching Aids

Demonstration lessons using pupils from our school were used to stimulate discussion about teaching methods. The inclusion of "live" lessons was a novelty as most of the Ministry's workshops are held over the holidays when there are no children to teach.

This [the lessons] clearly showed that staff development is not about reading papers and quoting prestigious authors or about bringing in expensive outside resource persons. It is about using the resources readily at hand—pupils, teachers, and district staff. (Workshop report: 03-04/02/94; p.15)

Local resource people were also available because of the timing of the workshop. Teachers from the schools taught two of the lessons and the lecturer from GTC taught the other two. In the evaluations, participants commented that the lessons were well-prepared, actively involved pupils, and used visual aids effectively. They "highlighted how to effectively teach concepts i.e. a few at a time rather than hurry and finish the syllabus." Some teachers felt that the lessons represented the everyday situations which classroom teachers faced but others thought that it would be more helpful to "concentrate on slow learners' classes as this is where teachers get problems."

The discussions started from observations made by the lecturer from the primary teachers' college one day and the HOD from one of the schools the next day. The fact that there were 52 children in 1A immediately prompted discussion about class size. Although teachers do manage to organise such large classes it is difficult and it "removes the zeal from teaching." Other discussion centred on the use and availability of teaching aids. To be effective each child should handle concrete objects; as this was not possible, and some children still did not get the concept, some teachers felt that perhaps it was better to adapt to the lack of resources.

However, participants agreed that without the tracing paper in the lessons on circle geometry the children would not have grasped the concept. "That made the teacher's day." For both of the lessons on circle geometry, one on the angle subtended by a diameter (3B) and the other on angles subtended by the same chord (3C), the children used tracing paper on diagrams they had drawn to establish that angles were congruent. In the first lesson, they checked the angles they had drawn in the semi-circle with those of other
students, and in the second lesson they compared angles drawn in the same segment of their own circle. In both lessons, the property was then used to determine angles in diagrams involving circles where some angles were given and some were unknown. The homework assignment was to investigate whether the property held for other angles in the circle, as well as to complete certain exercises from the textbook. The lessons modeled how a simple teaching aid could help students discover properties of circle geometry for themselves.

I had displayed teaching aids and samples of students’ work from the project around the perimeter of the hall where the sessions were held. Teachers’ comments about the display were positive. For example, some words used to describe the display of teaching aids were: “quite relevant,” “meaningful,” “effectively used,” “very refreshing and interesting,” “self-explanatory,” “good,” “constructive,” and “useful.” “A very good variety of media was used and covered most of the syllabus topics.” “The display quite clearly showed how they [teaching aids] could be consolidated into lessons.”

The display included geoboards illustrating various transformations which served as a focus for my presentation on teaching stretches and shears. We also played the isometry game in small groups during one of the sessions. The participants’ reactions to this were positive, for example: “Isometric game is quite good for consolidating all aspects of transformations” and “games were very helpful,” although it was judged more appropriate for “fast” than “slow” learners.

However, many teachers felt that more explanations would have been helpful. “This was done inadequately, there was need for some real demonstration of how to handle these [teaching aids, including geoboards].” Also, as in the discussions, there were some reservations about the use of teaching aids.

The emphasis should not be on having aids for every lesson. These should only be used when their use improves the chance of understanding the subject matter by students. Unnecessary use may affect syllabus coverage, hence the performance of pupils in exams. (Workshop report; 03-04/02/93; p. 10)

The larger group reflected the same concerns about using teaching aids as the Kwelo teachers had.
The lessons also led to discussion around another of the objectives: to provide some mathematics teaching resources to the cluster schools and to consider the establishment of a mathematics teaching resource centre. It was difficult to come to terms with the logistics of a resource centre. As most teachers do not have their own transport, locating a resource centre either at regional office or at one of the schools did not seem to be workable. The possibility of sharing resources was discussed, but the schools were too far apart for this to work either; it would be better for each school to have its own resources.

Problems and Concerns

Some of the teachers expressed dissatisfaction that the discussion was not limited to the lessons; "... people channeled the discussion towards their grievances." However, this discussion was not a digression; one of the objectives of the workshop was to bring teachers together so that this type of interaction could take place. As intended, the lessons served as a catalyst for discussing wider issues. As one participant commented in the evaluations, the lessons "gave people a starting point in discussing problems facing mathematics teachers and their pupils." However, the group felt they had no solutions for most of the issues raised.

Problems were cited in their large numbers; definitely, teachers have a lot of them. It is not surprising that some teachers reach a point of frustration. While it was hoped they might come up with some solutions, this was not the case. But, could they, especially on such matters as large classes, heterogeneous classes, and a single syllabus for too wide a range of abilities? At least it was good they had been given the platform as some of them were quite emotional about the problems. Perhaps the most that can be expected is that they do their best to swim in a sea of problems. Any attempts to improve the situation will require a positive attitude on the part of the teachers. (Workshop report: 03-04/02/94; p.11)

The discussion did capture the essence of the dilemmas teachers faced.

There was considerable discussion on the influence of examinations on teaching. Teachers feel pressure to cover the syllabus and it becomes a race for the pupils, and the slower ones fall out. But if teachers cater to these pupils, parents attribute the failure of their children to the teacher's failure to complete the
syllabus. There is a need, then, to educate parents. But it’s not that simple. As long as five O-level passes is the ticket to employment, society will demand that schools prioritise their brighter students. (Workshop report: 03-04/02/94; p.3)

A possible solution is to make the examination more suitable for the average student. But then “society” has to be willing to accept a change in standard or recognise an alternative credential.

But who is society? It is teachers, headmasters, parents, workers, and managers in industry and commerce. Most people have dual roles and may see the situation differently as educational professionals than they would as parents, employees, or employers. It still puts teachers in an unenviable position. ... it’s hard not to concentrate on the one or two competent children in some classes ... sometimes teachers just give up on classes. (Workshop report: 03-04/02/94; p.3)

As educators, the participants were still part of society; like other parents, they wanted their own children to have five O-levels. The possibility of having a core syllabus in mathematics, as in science, was raised. The point was made that many people have a negative attitude to core science.

Participants differed as to whether teachers should strive to bring the matters discussed to the attention of policymakers or to concentrate on improving mathematics teaching given the present constraints. The latter alternative was pursued in more depth. Streaming is common practice and right now most teachers respond to expectations by “covering the syllabus” with all the classes. But,

should 1A and 1Z be taught the same way? After all, they are likely to use their mathematics in different ways. It was agreed that it is necessary to stream the classes in some way but the psychological impact on both teachers and students in the lower classes is significant. Both give up and children are just “growing up in school.” We have to teach for understanding; the problem is not with the kids but with our approach. Perhaps we can identify key topics or teach the same topics to all but give more and different work to faster classes. (Workshop report: 03-04/02/94; p. 6)
The group recognised that adapting instruction to the ability level of the children was a reasonable response to student diversity. However, the examination dilemma remained.

But no matter what we do, only 20%, at best, will pass the test. This examination is not intended for our kids [in the cluster schools]. We’re trying to force them to do something they can’t do. Too much emphasis is being placed on the numbers [of children who] are failing. So should we just give up on these children? Should we encourage them to drop the subject? But the child is in a difficult position without mathematics. How much numeracy does one need? How does a child with five Us at O-level compare to a child who hasn’t gone to secondary school? (Workshop report: 03-04/02/94; p. 6)

The lecturer from the primary teachers’ college pointed out that some of their students had dropped mathematics at O-level because mathematics was no longer an entry requirement for primary colleges. The colleges now had to teach more mathematics content. How could the situation be improved if primary teachers did not have a good foundation in mathematics?

The discussions were labeled by the teachers as “good,” “meaningful,” “interesting,” and “pertinent.” However, “the problems are country-wide and hence may take a long time to change i.e., big numbers, community poverty.” Some teachers just wanted to concentrate on their teaching and felt that policy issues were not their concern. “If these could be taken up to those who can best give solutions as some of them are a matter of policy which we can’t change.” Others, however, wanted to advocate for change.

The Cluster Concept

As Mr. Mukoyi explained in his opening remarks to the workshop, the Ministry’s priority was no longer expansion but improving the quality of teaching and learning. The Ministry wanted headmasters to manage schools better, and teachers to improve their practice. The workshop was intended to set an example of what could be done by working together within the cluster. This comment by one teacher captured the spirit of the concept:

When we are out in our schools we just feel that we are the only ones with certain problems. Now I have realised that we all
have problems and we need to solve them together. (Workshop report: 03/02/94; p.7)

The participants thought the idea was good but they also commented that putting it into practice would require commitment on the part of both headmasters and teachers. Teachers expressed concern about the basis upon which the schools were grouped. The grouping was not intended to be former group A schools versus former group B schools but boarding versus day schools in the same geographical area. These schools were likely to share the same concerns. The schools in the cluster, both primary and secondary, were all day schools and enrolled a greater proportion of non-academic students than some of the other urban schools in the area. Still, the participants felt that the mechanics of forming the clusters and making them operational might require further thought; they felt that segregation from the former group A schools would perpetuate and accentuate differences which already existed. There should be “follow-up by the EO and HODs to see what schools are doing and give encouragement.”

**Follow-up to the Workshop**

In fact, our proposal had included a follow-up meeting with the HODs to review the experience and decide what further action to take, as well as visits by the EO to assess the impact in the schools. The HODs met on 18/02/94. They were pleased with the contributions of the resource persons but thought that, another time, tea and lunch should be provided at less expense and that more effort had to be made to avoid disrupting other departments. As an outcome of this meeting, a set of twenty compasses, protractors, and set squares were provided to each school, as well as class sets of small mirrors. In addition, graphboards, made by a local sign writing firm, and demonstration geoboards, made at one of the schools, went to each school.

Mr. Shiri later wrote (16/07/94) to comment on Africa Reports and to inform me of developments regarding the workshop:

I have hardly been in my office since the beginning of term in May. However, I have met [the HODs of two of the cluster schools] who indicated that there was a lot of enthusiasm to try and pursue some of the workshop ideas at their schools. On my own part, I still hope to visit some of these schools to follow up.
as soon as I get a week when we are not going out. So far this has been extremely difficult. ... The report has been circulating within our offices and the DRD has also read it. It was all commendation from everyone. Head office also responded and expressed their gratitude over our having been able to hold such a successful workshop for teachers. I believe that when I take up the issue further, I should get support! ... Obviously I am still determined to see to the establishment of a resource centre and follow-up visits to the cluster. Time has simply not been on my side. Remember I am all by myself to look after the Mathematics interests of all the 225 schools.

Certainly, at the time, there had been a great deal of enthusiasm. But what about the impact of the workshop in the long run? It seems, at least in the short term, the cluster concept did not continue along the lines the teachers and headmasters had envisioned.

Mr. Mukoyi wrote (28/10/94):

The cluster is quite dormant now but I have requested Mr. Shiri to probe other subject EOs with a view to holding workshops like we had for Math. People still express admiration for how it was done. Math teachers have received the [geo]boards made at [one of the cluster schools]. 139 pupils out of 193 have registered for O-level math in the school this year. Very encouraging if compared with previous entries.

Mr. Phiri and I kept up a correspondence. He informed me (11/05/95):

The workshop we held during your stay at Kwelo will remain a memorable event in my teaching career. Unfortunately, though, no communication is taking place among HODs of the Maths Departments of the cluster schools. Problems of communication [transportation, telephone] are the main cause for this lack of communication. We occasionally bump into each other in town.

I later learned from Phiri (26/05/95) that only he and Mabasa were left in the department; the others had transferred. Mr. Mtisi was now headmaster at another school, Mr. Shiri had been promoted to EO Planning, and Mr. Mukoyi was on leave doing an MEd in Administration at the University of Zimbabwe. Phiri said that two of the new teachers were straight from college and that they were enjoying using the equipment. They were also running a Maths-Chess Club.
Evaluation of the Workshop

So, what is effective in-service in the context? If change is desirable, how should it happen? The workshop was a useful model. It was endorsed by the Ministry and the structure of the system facilitated planning and organising it. The HODs took responsibility and they were close enough to day-to-day teaching to know what was important to teachers. The fact that the education officer, the headmaster of the host school, and the HODs were directly involved meant that teachers took it seriously. It was low cost. WUSC provided the money, but this was mostly spent on food and resources. Comparable funding was available from the Ministry; it was just more difficult to access. Resource persons were drawn from the local educational community; they shared the concerns of teachers. Because teachers’ college lecturers are in the schools on a regular basis supervising student teachers they are familiar with conditions in the schools. Although I was an expatriate researcher from Simon Fraser University, I was also just another lecturer from GTC. In any case, my role was minimal in contrast to the other projects I visited which were dominated by expatriates. The demonstration lessons encouraged teachers to reflect on their practice. The teaching aids provided a focus for the activity. Another time, the focus could be different. It was possible to get teachers themselves to participate in a learning activity—both groups had enjoyed playing the isometry game. It was easy to obtain cooperation between the teachers’ colleges, regional office, primary and secondary schools, and within the school. The combination of top-down and bottom-up approach which we used to plan the workshop was dependent on the administrative structure of the Ministry and the cooperative nature of participants, both strengths of the Southern African context. However, without being embedded in the cluster concept for school improvement, the workshop could easily be just another “one-off” affair. Communication problems and loss of leadership seemed to be factors working against the continued development of the cluster. Perhaps it is too early to judge. Maybe the cluster is only “dormant” as Mr. Mukoyi described it and can be revived readily in the future.

The workshop had a greater impact on the mathematics teachers at Kwelo than my project alone.

I was quite glad about the whole idea of your project. Although we didn’t have enough time ... When you go we will try and use
them [the teaching resources] effectively whenever it is possible. If it is not possible to use them in classes, when there is extra time then we might use them. Those which we can use in class we are going to use because it is quite interesting. When we were doing that game it was quite interesting and if we bring that in a classroom situation people will say that mathematics is not just ... [inaudible] ... we have some other goals. Some kids are good at that. What we discussed in that seminar is going to help us. Maybe we are actually going to look at the problems, maybe we are going to solve them. Maybe next time you come or when you write or we write you, we will be able to tell you that because of that seminar now things seem to have improved.

(Mugedeza, interview #2)

The workshop, however, grew out of the project. Without my time in the school, the collaborative relationships which made it happen would not have existed; I would not have understood the problems well enough to play a useful role; nor would I have been able to mount a display which showed how the teaching aids were used in actual lessons.

The last chapter summarises what I learned with reference to the original objectives and research questions, evaluates the project, and argues the merit of doing similar ethnographic classroom research in Zimbabwe.
student geoboards at GTC
"the teacher had his own—a large one for demonstration" (p.170)
Chapter Nine
Summary and Conclusions

In this chapter I first respond to the initial objectives and research questions. Then I summarise what I learned both about worthwhile change in the context and about effective change processes. Finally I reflect on the methodology of the project with the intent to highlight advantages of using ethnographic methods for classroom research.

Response to Original Objectives and Research Questions

The original objectives of this study were to produce modular materials to help teachers plan lessons which used a variety of methods, to develop these through a model of in-service involving reflective practice, and to assess and evaluate the effect of this experience on both teachers and students. These original objectives were based on the assumption that implementing the teaching methodology described in the syllabus would have a significant impact on learning and help to improve the situation in the schools.

It turned out that the teaching aids had a greater impact than the print materials, which had none. The teachers did not appreciably change their methods in response to my presence and the extra teaching materials. They did, however, reflect on their practice in response to the interviews, daily interactions, and the workshop. There was no evidence that the achievement of students was affected by the project, either positively or negatively. There was evidence that the majority of students enjoyed learning through activities and working in cooperative small groups. Some of my students were confused, partly because I had changed their routine and partly because they had difficulty understanding me. A number of students responded negatively to the kind of problem solving activities we did in the mathematics club. Unexpected results were the reaction of my students to a change in the marking routine and to the noise level when working in small groups. By the end of the project I thought addressing issues surrounding curriculum and assessment would do more to improve the situation in the schools than changing teaching methods.

I wanted to answer the question: How can in-service for mathematics teachers address their concerns? A number of factors limited my model of reflective practice, the most important being that the other teachers did not
share my motivation to change practice and that the teaching methodology did not address many of the problems they faced. The amount of release time gained by taking one class from each teacher was insignificant as they still needed to do preparation for other classes in that form. Although the relief was appreciated, it was used for marking, not for preparation or "reflection" on teaching. I had limitations as a change agent. As a novice researcher, an expatriate with a different educational paradigm, and no second language, I was not an ideal facilitator, despite my experience in the system. But local people to fill similar roles were not readily available—I was what was feasible in the circumstances.

The cluster workshop was a useful model for in-service because it provided opportunity to interact with teachers in other schools and because it was part of a larger Ministry initiative. However, it was apparent from the workshop that some teachers, even though they saw a need for change, did not see themselves as having a role in change. If in-service is to address teachers' concerns in any meaningful way, teachers must be part of the solution to the problems they face. The cluster has the potential to help; it was unfortunate that it did not continue to meet.

My other question is difficult to answer: what is appropriate mathematics curriculum for the majority of students? Certainly, not all children will pass O-level. When the syllabus was drafted (pre-1991) the community had not been willing to accept an alternative to O-level and Cambridge O-level examiners were not willing to endorse an O-level core curriculum, although educators advocated it. "Covering the syllabus" was a recurring theme in all my conversations with teachers. Both teachers and students affirmed that the majority of the students cannot assimilate the material at the rate at which it is taught. Teachers were not comfortable about developing a school core syllabus without official approval from the Ministry. In my opinion, a core curriculum has more merit than an alternative curriculum of the F2 variety, which the teachers remembered and referred to in my discussions with them. A core curriculum would give teachers and students more time to learn while still allowing students to learn more mathematics which they may well need in the future. More students might pass the O-level examination. It is understandable that the community is reluctant to relinquish the O-level as it is a reasonable standard with international respectability. Perhaps ZJC should be an acceptable standard for
school completion and everyday competence. Other countries share this curricular dilemma and, to my knowledge, none has resolved it satisfactorily.

The focus of my project changed from implementing the syllabus statements to evaluating them. I wanted to answer the questions: What was the origin of the methodology statements? Which of them represented worthwhile changes in the current context? My investigations regarding the syllabus led me to believe that, rather than being grounded in current realities of education in Zimbabwe, the methodology statements reflected what was current in the international mathematics education literature. Based on my own teaching experience, discussions with the teachers, and feedback from students, I evaluated the suggested changes according to Fullan’s three criteria: are they needed, are they technically sound, and are they feasible in the circumstances?

The "What" of Educational Change

To improve the teaching and learning of mathematics it is important to first advocate worthwhile change. In retrospect, what do I consider to be worthwhile change in the context?

Assessment

In my view, the most important educational change to make at the classroom level is related to assessment. If teachers used assessment procedures to explore the boundary between what the children know and do not know, rather than modeling all their tests on the ZJC and O-level examinations, the information they gained could be used to support learning. Teaching 1A and 1F from the same scheme and having them write the same tests and examinations makes little sense; the zeros serve no educational purpose. Linking assessment more closely to the teaching-learning process would not necessitate a change in the examination system, or even reporting procedures. It would not mean leaving children’s work unmarked or not assigning written work. It would mean giving teachers greater latitude to exercise their professional judgement. All of the mathematics teachers had adapted the expected marking in some way so that they could manage and still provide useful feedback to students. The school administration was starting to encourage teachers to adapt their assessment strategies to the ability level of their students. With this kind of support, teachers will find what
works best to foster learning. The syllabus methodology suggestion that students “check and criticise their own work” does not capture what is needed; rather, teachers need to find out what children do know so that they can build on that knowledge.

The international reform agenda in mathematics education is predicated on changes in assessment practices—encouraging problem-solving and investigative work requires a teacher component to summative assessment and/or modification of the nature of the examination. However, these trends in assessment are in response to different circumstances, problems, and traditions and have not yet played out (i.e. proven to be technically sound) in other settings. As well, most teachers in Zimbabwe are used to preparing students for the primary-leaving, ZJC, O-level, and A-level examinations and have had little or no experience with teacher-based assessment for evaluation. Strong community/parental expectations exist about what constitutes fair assessment and evaluation. “Fair” is generally interpreted to mean treating children the same. Because teachers are accountable for the children’s success on examinations and because the stakes for success are so high, parents and children are likely to attribute failure to the teacher. This was a major reason why teachers were concerned about “covering the syllabus” with their classes even when it seemed inappropriate to them. Because formative assessment is integral to what teachers and students do everyday in the classroom, it is feasible in the circumstances. It would be more difficult to implement teacher-based assessment for summative purposes, including report cards, for the reasons given. Are changes in examination practices needed or feasible?

Teaching Methods

The international literature of mathematics education is promoting a “constructivist” approach to mathematics teaching which acknowledges what children already know and encourages them to talk about what they are learning. Reports on science and mathematics teaching in the region criticise “chalk and talk,” recommending more active involvement of pupils in their lessons. The syllabus suggests that abstract concepts be developed from the concrete and familiar. It advocates guided discovery and activity-based discovery as a means of providing sound understanding of concepts. It
recommends regular use of group-work and an emphasis on problem-solving in familiar and unfamiliar contexts, as well as project work and the reinforcement of skills taught in other subjects. At GTC we were encouraging our students to make more use of "teaching aids"; for example, in the mathematics department we required students to make a demonstration geoboard which they then took into the schools with them.

Given the numbers of children per class and the emphasis on preparation for examinations, implementing project work in the classroom did not seem feasible. My attempt to address problem-solving in the mathematics club met with little success. I did integrate mathematics with other subject areas in some lessons. Using a variety of teaching aids for demonstration and for activity-based learning in small groups was the major change which I tried to implement in the classroom. I had brought some of the teaching aids from Canada (for example, cards, dice, student geoboards) but obtained others locally (for example, wire toys, maps, and samples of material).

In reviewing curriculum projects in the 1960s and 1970s Howson concluded that the "formative" projects were the most successful because, compared to other projects, they were more closely connected to classroom realities and to the way students learn. The failure of SMEA (a formative project) in rural schools in East Africa has been attributed in the literature to teaching methods which were inappropriate for the context. In this study, students responded positively to group-work and activity-based learning, (although there was no evidence that this affected their achievement). The children affirmed that activity-based learning provided greater conceptual understanding and that talking to each other in small groups helped them to learn. Most children did not like to speak out in class because they were "shy" and because they were learning in a second language. It was very natural for them to cooperate. Ascot was typical of many schools in Zimbabwe and Phiri was more effective than I doing the same activities with the children. The study has shown that there is an alternative to "chalk and talk" for mathematics teachers in Zimbabwe; it is possible to deviate from the common routine of mathematics teaching: exposition, examples, and homework exercises.

A significant majority of the children were uncomfortable with noise generated by discussion, whether it was on or off task. Their reaction
highlights the importance of the mathematical task, the teacher’s classroom management skills, and student expectations about learning. There must be something meaningful to talk about; without a worthwhile mathematical task which can be attempted by all children the discussion may serve no educational purpose. My tasks were meaningful but, judging from student feedback, I did not pay enough attention to management issues, nor did I succeed in getting all children involved. Children are used to silent classrooms and encouraging them to talk, without very sound pedagogy, may be counterproductive.

Core Curriculum

Teachers do not do practical activities because they are “time-consuming.” Two ways to obtain more time for teaching are to teach less content and to extend time in class. Both of these have potential for increased success at O-level. Our attempt at establishing a core curriculum for the school was not successful, partly because teachers did not feel that they had the professional latitude to do this. It seems that children would respond to a core approach, as the “slow, dull, poor” students want to go slower and the “fast, bright, good” students are willing to do extra work. However, this is complicated by parental expectations about curriculum and assessment, as evidenced by the children’s frustration at not having their daily exercises marked.

Parents want their children to succeed in school and success is measured by achievement on classroom tests and the examinations. It is very difficult to separate issues of certification and selection from teaching issues when discussing curriculum. This is particularly so in the socio-political context of education in Zimbabwe where limited access to schools has generated unrealistic expectations of the value of an O-level certificate. Also, issues regarding curriculum and assessment are particularly problematic in mathematics. Other educational systems have not satisfactorily resolved the alternative curriculum debate or the role of mathematics as a “gatekeeper” subject. Even if curricular decisions are made at the Ministry, they will not be immediate and will face formidable implementation difficulties. In the meantime, teachers and students must go to school and cope with what is. I think a core school syllabus has potential to help in the here and now.
In summary, although the project provides some support for pursuing activity-based learning in small groups, these methods are not a panacea for the children's problems with learning mathematics. My thoughts on formative assessment and core curriculum are speculative. I think these changes are needed and feasible in the circumstances but only by attempting to put them into practice will it be possible to assess whether or not they address the concerns expressed in the thesis.

The "How" of Educational Change

It is important to first advocate worthwhile changes and then to implement them effectively. What did I learn about effective change processes?

Individuals Can Make a Difference

As Fullan emphasises, change is a highly personal experience and each of us must work through it in our own way. In response to Africa Report #3 (16/07/94), Mr. Shiri commented:

On your feeling of being discouraged and frustrated because teachers were not responding as you expected. I think I made my point on this one before. Your success should not be measured on the extent of whether or not they would do as you wanted. Personally I am convinced that even if the response is negative and there are explanations, I should still consider the research a success. Perhaps time will tell. I have a feeling that at times change takes time to sink and be part of the system. ... I would just want to say that while you may not have thought you were successful, at least people (teachers) are thinking about some of those ideas. I believe this will further develop into full scale action especially if the cluster continues to meet and teachers give each other support.

In retrospect, my expectation that teachers would change their practice in response to my presence seems naive and I wonder that I was so frustrated.

Whatever effect the project may have had on other teachers, it had a profound effect on me. I tried hard to model the syllabus statements and, in the process, I changed my own practice. Documenting the experience with field notes and writing a thesis involved a great deal of reflection about teaching, learning, and the change process. Certainly, in response to my
presence in the school and to the workshop, the other teachers did reflect on their practice. Phiri later (11/05/95) informed me that the equipment was being used, particularly the geoboards. The playing cards, geometric solids, and dice were also popular. At the time, the teachers told me that the extra time and effort required to prepare for lessons using the resources was a factor curtailing their use, particularly as they were not sure how to use them. As Mr. Shiri reassured me, I did make a difference; each of us must work through change in our own way and in our own time.

Mr. Shiri (16/07/94) wrote about another individual who was making a difference:

I thought I could also share this experience with you. When I went to Mberengwa, one young teacher was teaching transformations. To my amazement, he had a full set of geoboards for the class (each pupil had his/her own) there were 36 of them. The teacher had his own—a large one for demonstration. They also had rubber bands of different colours. The lesson went very well and I was most impressed with its success. On discussing with him and the Head, I was informed that the young teacher (two years experience) had put so much pressure on the Head to have these made. The question is—do people have to attend in-service to put such ideas into practice? This young man had attended no in-service since the completion of his training. I thought that this is a good example of what a determined teacher can do—the school is rural and poor and I really felt that the kids were gaining much more here!

The young teacher was likely a recent graduate of GTC. Mr. Shiri’s anecdote supports Fullan’s ideas about the importance of the individual in effective educational change and Merkus’s analysis that what teachers need is not necessarily formal in-service focused on changing teaching methods. Exposure to ideas along with support in their efforts to effect change will probably do more to improve practice than isolated in-service training events. In my view, if teachers are to make a difference as individuals, they need to be trusted more and encouraged to seek answers to the problems they face every day in the classroom.
Collaboration

Fullan suggests that effective educational change requires encouraging and giving assistance to people who are acting in purposeful ways. It is the actions of individuals, working together, which make a difference. SFU developed the program in mathematics education as a way of influencing change in schools. The program targets teachers who want to improve their practice. SFU supported my proposal to do the thesis work for my degree in Zimbabwe. Without approval from the Ministry, assistance through WUSC’s Associate Program, and Mr. Shiri’s cooperation, the project would not have come to fruition. The Ministry, at both national and regional levels, further supported Mr. Shiri and me. The fact that WUSC and the Ministry were already collaborating in promoting the cluster concept was crucial to the role the organisation played in our workshop.

Fullan (1993) writes “... in cases of eventual success there are great highs, ecstatic feelings of accomplishment, and moments of deep personal satisfaction and well-being (p. 25).” This aptly describes our feelings at the time of the workshop.

Things seem to be coming together very well. Finally, I have a feeling things are happening as they should and am quite excited. We’ve all worked together: WUSC, EO, headmaster, HODs on planning this workshop and others seem quite keen as well, even teachers, (that is why I am). It may be that I’m getting the pay-off for doing this kind of research—I’m more in the picture now and part of the scene. (And I wouldn’t be without my problems and frustrations). (Africa Report #6.)

The EO, headmaster and HOD, and other participants all expressed similar positive feelings. It was personally very satisfying to work together with common purpose.

Expatriate organisations can be useful collaborators because they provide funding and because they can cut through government bureaucracy. It was easier for us to access funding for our workshop through WUSC than through the Ministry. The administrative structure of the Ministry makes it difficult for administrators or teachers to initiate projects at the local level. In my view, individual expatriates are involved in education in Zimbabwe as much because they have time and energy, and money through their organisations (as was the case in organising our workshop), as because they
have special expertise. Local people with expertise are usually overloaded at work and have survival concerns and family obligations. Tapping the local expertise is essential for effective change, though. There are two difficulties with expatriates in the role of change agent. One, initially, we do not know the context; by the time we do, we are often gone. Two, we carry our paradigms with us and often do not examine our own assumptions.

The insider/outsider perspective of an effective change agent can arise in a variety of ways. I had been educated in a different, North American tradition and both my experience at the teachers' college in Zimbabwe and my program at SFU had caused me to think seriously about the teaching and learning of mathematics. In this project, my colleague from the teachers' college and the EO both had master's degrees in mathematics curriculum from the University of Zimbabwe and the former had studied and worked in Britain. A change agent can be anyone with expertise and a different perspective who wants to make a difference.

Given the political urgency to provide mass education in Zimbabwe few, if any, of the many educational changes experienced since independence have had the luxury of being piloted in the schools. The workshop was an example of what can be achieved through collaboration of the schools, the colleges, and the regional office of the Ministry. If a local college initiated an action research program involving practising teachers, student teachers, and lecturers, the research could address concerns at the school level while contributing to a literature of educational research grounded in the context. Such a program in line with Ministry priorities could provide a source of topics for projects by student teachers (college certification and BEd degrees) and dissertations at the master's level. EOs and lecturers would gain from closer contact with the schools. Student teachers could provide teachers with the extra time they would need to put into practice changes they wanted to make. Also, student teachers, who are often just swallowed up by the system, would have an opportunity to try out new ideas. A person in any of the roles: headmaster, lecturer, EO, student teacher, or teacher could act as the major change agent. Such action research groups could provide a focus for the cluster. Research could be published, with increasing rigour, in a college newsletter, Teacher in Zimbabwe or the Zimbabwe Journal of Educational Research.
In summary, the project provides evidence that individuals can make a difference and that meaningful collaboration is possible. However many questions remain. Is it feasible to combine the cluster concept and my original school-based model of effective practice? What would it take to keep the cluster focused and committed to continued collaboration?

Importance of the Ethnographic Approach to Educational Research for this Study

The preceding discussion illustrates how important the ethnographic approach to my study was. Despite previous experience in the educational system, I needed the greater understanding which the participant observer role in the township school provided. Only by being a teacher in the setting could I appreciate how other teachers felt. Feedback from students provided additional insight to that gained from classroom interaction. I came to appreciate the pressure the school was under to increase the pass rate as well as the children's problems with curriculum and language. Without my previous experience, the time in the school, and my exploration of other in-service projects, I would not have understood the perspectives of participants and the contextual factors operating well enough to play a useful role in the cluster workshop. It was the ethnographic nature of my project which allowed us to conceptualise the workshop.

At the same time, my experience in Zimbabwe made me question the relevance of much of the current reform agenda in mathematics education especially for contexts other than North America where most of the research upon which it is based has been done. I found that implementing the methodology statements was not the key to improved practice that I had originally thought based on my teaching practice observations and subsequent reading.

As a participant observer, I was both an insider and an outsider. The fact that I came from a different educational paradigm meant I questioned things others took for granted. An example of this is the marking routine. My reaction to this led to the hypothesis that a key to helping students learn better is to match marking and assessment procedures more closely to instruction and learning. Also, I was used to universal secondary education in Canada. Largely because of this paradigm it was important for me to
explore the possibility of introducing a core curriculum as a way of helping the majority of students in the school.

When it became apparent that producing curriculum materials with the other teachers was not realistic, I was able to adapt and concentrate on evaluating the statements. Rather than continue to accept these statements about teaching methods in the syllabus as a given, I explored the background to the current syllabus. I had not expected to do this; it was not part of the design of the study. Whereas originally the study focused on teaching methods, I later became more concerned about curriculum and assessment issues. When my proposed model of teacher development did not seem to fit the needs of the situation, we (the EO, HOD, and I) were able to examine other alternatives, leading to the cluster workshop. These developments all underscore the advantage of the flexibility of ethnographic methods for research in education.

To improve practice it is necessary to get beyond the rhetoric to the reality of change. I hope that this thesis will serve as an example of the potential of classroom-based research to address important educational concerns.
List of References


GENERAL CERTIFICATE OF EDUCATION

O Level Syllabuses 1991
for Candidates in Zimbabwe

MATHEMATICS (4008, 4028)
PREFACE

In 1991, the following fifteen syllabuses will be examined jointly by the Ministry of Primary and Secondary Education in Zimbabwe and the University of Cambridge Local Examinations Syndicate for the 'O' level examination in Zimbabwe. They replace the Ordinary level syllabuses previously offered by UCLES. Further syllabuses will become available in subsequent years. Until such time, candidates may continue to enter for some 'O' level syllabuses published in the syllabuses for International Examinations by UCLES, as agreed by UCLES and the Ministry.

Specimen papers and marking guidelines will be issued for each subject a few months after the publication of the syllabuses.

1122  English Language*
2013  Literature in English*†
2042  Religious Studies A*†
2043  Religious Studies B*†
2166  History*†
2248  Geography*
4008/4028  Mathematics*
5006  Science*
5007  Extended Science*
6035  Woodwork†
6045  Metalwork†
6051  Fashion and Fabrics
6064  Food and Nutrition
7103  Commerce*†
7112  Principles of Accounts*†

[*Also available in June 1992 examination]
[†New subjects available for the first time in November 1991]
GENERAL INTRODUCTION

Since 1980, when Zimbabwe came into being, there have been considerable institutional changes in response to national needs, goals and aspirations. In the field of Education, the government has democratized educational opportunities by making both primary and secondary education available to almost all children of school-going age.

The long-term implications arising from this tremendous and rapid expansion are that:

a) the majority of Zimbabwean pupils are unlikely to find places in institutions of higher training and learning. The Ordinary level Examination will, therefore, be a terminal one for this majority before they go out to work;

b) education, particularly at secondary level, should prepare pupils for the world of work and at the same time provide opportunities for admission to institutions of higher learning for those qualified.

Arising out of the above it has been found necessary to initiate curriculum change, as an on-going process, in order to:

c) incorporate within the education system values that are consistent with the social and political aspirations of Zimbabwe, e.g. the inculcation of a work ethic and the usefulness of productivity, patriotism, co-operation and an understanding of Zimbabwean regional and world history, culture, politics and ideology;

d) provide the many who are not likely to go on to higher learning institutions with an education which will be functionally useful in the world of work. The integration into the curriculum of the philosophy of Education with Production is aimed at helping pupils to relate knowledge and theory to their practical application in production within the Zimbabwean context;

e) incorporate social, scientific and technological content and concepts wherever possible across the curriculum so that this essential knowledge is accessible to as many people as possible.
Subjects 4008/4028. MATHEMATICS

(N.B. This syllabus replaces Subjects 4004 and 4024)

4008. This version is for candidates not using calculators
4028. This version is for candidates using calculators in Paper 2
1.0 PREAMBLE

In designing the syllabus, due consideration was paid to each of the following:
- the needs of the Zimbabwean pupil, those of the nation as a whole in a socialist context as well as the nature of Mathematics;
- the existence of a wide range of abilities in schools;
- the nature of available resources.

The result is a syllabus which caters for those who intend to study mathematics and/or related subjects up to and beyond "O" level, or enter into professions which require a solid mathematical background.

2.0 THE SYLLABUS AIMS

To enable pupils to:

2.1 understand, interpret and communicate mathematical information in everyday life;
2.2 acquire mathematical skills for use in their everyday lives and in national development;
2.3 appreciate the crucial role of mathematics in national development and in the country's socialist ideology;
2.4 acquire a firm mathematical foundation for further studies and/or vocational training;
2.5 develop the ability to apply mathematics in other subjects;
2.6 develop the ability to reason and present arguments logically;
2.7 develop the ability to apply mathematical knowledge and techniques in a wide variety of situations, both familiar and unfamiliar;
2.8 find joy and self-fulfilment in mathematics and related activities and appreciate the beauty of mathematics;
2.9 develop good habits such as thoroughness and neatness, and positive attitudes such as an enquiring spirit, open-mindedness, self-reliance, resourcefulness, critical and creative thinking, cooperation and persistence;
2.10 appreciate the process of discovery and the historical development of mathematics as an integral part of human culture.

3.0 ASSESSMENT OBJECTIVES

Students will be assessed on their ability to:

3.1 recall, recognise and use mathematical symbols, terms and definitions;
3.2 carry out calculations and algebraic and geometric manipulations accurately; check the correctness of solutions;
3.3 estimate, approximate and use appropriate degrees of accuracy;
3.4 read, interpret and use tables, charts and graphs accurately;
3.5 draw graphs, diagrams and constructions to give appropriate specifications and measure to a suitable degree of accuracy;
3.6 translate mathematical information from one form into another (e.g. from a verbal form to a symbolic or diagrammatic form);
3.7 predict, draw inferences, make generalisations and establish mathematical relationships from provided data;
3.8 give steps and/or information necessary to solve a problem;
3.9 choose and use appropriate formulae, algorithms and strategies to solve a wide variety of problems (e.g. agriculture, technology, science and purely mathematical contexts);
3.10 apply and interpret mathematics in daily life situations.
4.1 S.I. units will be used in questions involving mass and measures; the use of the centimetre will continue.

4.2 The time of day may be quoted by using either the 12-hour or the 24-hour clock; e.g. quarter past three in the morning may be stated as either 03 15 a.m. or 3.15 a.m.; quarter past three in the afternoon may be stated as either 15 15 p.m. or 3.15 p.m.

4.3 Candidates will be expected to be familiar with the solidus notation for the expression of compound units e.g. 5 cm/s to 5 centimetres per second, 13.6 g/cm³ for 13.6 grams per cubic centimetre.

5.0 METHODOLOGY

In this syllabus, teaching approaches in which mathematics is seen as a process and which build an interest and confidence in tackling problems both in familiar and unfamiliar contexts are recommended.

It is suggested that:

5.1 Concepts be developed starting from concrete situations (in the immediate environment) and moving to abstract ones;

5.2 Principles based on sound understanding of related concepts, and whenever possible, be learnt through activity-based and/or guided-discovery;

5.3 Skills be learnt only after relevant concepts and principles have been mastered;

5.4 The human element in the process of mathematical discoveries be emphasised;

5.5 An effort be made to reinforce relevant skills taught in other subjects;

5.6 Pupils be taught to check and criticise their own and one another’s work;

5.7 Group work be organised regularly;

5.8 A deliberate attempt be made to teach problem-solving as a skill, with pupils being exposed to non-routine problem solving situations;

5.9 Pupils be taught to identify problems in their environment, put them in a mathematical form and solve them e.g. through project work.

6.0 CONTENT/TEACHING OBJECTIVES

All pupils should be able to:

6.1 NUMBER

6.1.1. Number concepts and Operations.

- Number types (including directed numbers, fractions and percentages)
  - Demonstrate familiarity with the notion of odd, even, prime, natural, integer, rational and irrational numbers, (including surds), e.g. by giving examples or by correct use of terms, and use of the number line;
  - Recognise equivalence between common/decimal fractions and percentages, convert from one to the other and use these three forms in appropriate contexts;
  - Use directed numbers in practical situations (e.g. temperature, financial loss/gain);
  - Find and use common factors/multiples, HCFs and LCMs of given natural numbers;
  - Apply the four operations and rules of precedence on natural numbers, common/decimal fractions, percentages, integers, and directed numbers (including use of brackets);

- Factors, multiples, HCF, LCM

- The four operations (+, −, ×, ÷) and rules of precedence
6.1.2. Approximations and estimates

- Use the approximation sign ($\approx$ or $\approx$) appropriately.
- Make estimates of numbers and quantities, and of results in calculations.
- Give approximations to a specified number of significant figures and decimal places.
- Round off to a given accuracy.
- Round off to a reasonable accuracy in the context of a given problem.

6.1.3. Limits of accuracy

- Obtain appropriate upper and lower bounds to solutions of simple problems (e.g., calculation of area of a rectangle) given data to a specified accuracy.

6.1.4. Standard form

- Express in, and use the standard form $A \times 10^n$ where $n$ is an integer (including zero) and $1 \leq A < 10$.

6.1.5. Number bases

- Do the following in bases 2, 5 and 10:
  - State and use place value.
  - Add and subtract.
  - Convert from one base to another.

6.1.6. Ratio, proportion and rates

- Use ratio, direct and inverse proportion (including use of unitary method) and rates (e.g., speed, cost per unit area).

6.1.7. Scales and simple map problems

6.2. Sets

6.2.1. Language and notation

- Define sets by listing and describing.
  - E.g. $V = \{a, e, i, o, u\}$ or $V = \{vowels\}$.
- Define sets using the set builder notation.
  - E.g. $A = \{x: x \text{ is a natural number}\}$
  - $B = \{x, y \in \mathbb{R} : mx + c\}$
  - $C = \{x: x = n\}$.
- Correctly use symbols as follows:
  - Is an element of $x$.
  - Is not an element of $y$.
  - Number of elements in set $A$, $n(A)$.
  - Complement of set $A$, $A'$.
  - The universal set $U$.
  - The null set, $\emptyset$.
  - $A$ is a subset of $B$, $A \subseteq B$.
  - $B$ is contained in $A$, $B \subset A$.
  - Union of $A$ and $B$, $A \cup B$.
  - Intersection of $A$ and $B$, $A \cap B$.
- Use the idea of complement of a union or an intersection.
- Use the following symbols:
  - $\cup$, $\cap$, $\subseteq$, $\supseteq$, $\emptyset$.
- Use sets and Venn diagrams to solve problems involving no more than three sets and the universal set.
CONSUMER ARITHMETIC

6.3.1. Interpret data (including data on real life documents like water/electricity bills, bank statements, mortgages and information in the media);

solve problems on budgets (e.g. household, cooperative and state budgets), rates (including foreign exchange and household rates), insurance premiums, wages, simple interest, discount, commission, depreciation, sales/income tax, hire purchase, and bank accounts (savings and current accounts);

read, interpret and use data presented in charts, tables, maps and graphs (e.g. ready reckoner, road maps, charts and graphs in newspapers).

MEASURES AND MENSURATION

6.4.1. Measures
- time
- SI units

6.4.2. Mensuration
- perimeter

read time on both the 12 and 24 hour clock;

use SI units of mass, temperature, length/distance, area, volume/capacity and density in practical situations, and express quantities in terms of larger or smaller units;

carry out calculations involving the perimeter and area of a rectangle, triangle, parallelogram and trapezium;

the circumference of a circle and the length of a circular arc;

the area of a circle and the area of a sector of a circle;

the volume of a cylinder and of a prism of uniform cross section;

the surface area and volume of a cuboid, pyramid, cone and sphere;

(formulae for surface areas and volumes of pyramid, cone and sphere will be provided);

(units of area to include the hectare);

GRAPHS AND VARIATION

6.5.1. Coordinates

Use cartesian coordinates in two dimensions to interpret and infer from graphs and to draw graphs from given data;

6.5.2. Kinematics
- travel graphs
- speed/velocity
- distance/displacement
- acceleration

draw and interpret displacement-time and velocity-time graphs and solve problems involving acceleration.
6.5.3. Variation
- direct
- inverse
- partial

express direct, inverse, joint and partial variation in algebraic terms and hence solve problems in variation;
draw and interpret graphs showing direct, inverse and partial variation;

6.5.4. Functional graphs

construct tables of values, draw and interpret given functions which include graphs of the form
\[ y = mx + c, \quad y = ax + bx + c \text{ and } y = ax^2 \]
where \( n \in \{-2, -1, 0, 1, 2, 3\} \) and simple sums of these;
use the \( f(x) \) notation;
solve linear simultaneous equations graphically;
solve equations using points of intersection of graphs i.e. drawing
\[ y = \frac{1}{x} \text{ and } y = 2x + 3 \]
to solve \( 2x + 3 = 1 - 0 \);

- solution of equations
estimate gradients of curves by drawing tangents and hence estimate rates of change (e.g. speed, acceleration);
find turning points (maxima and minima) of graphs (calculus methods not required);
calculate the gradient of a straight line \( (y = mx + c) \) from the coordinates of points on it, interpret and obtain the equation of a straight line in the form \( y = mx + c \);

- gradients and rates of change
identify parallel straight lines using gradients;
estimate area under a curve by counting squares and by dividing into trapeziums (trapezium rule not to be used);

6.6 ALGEBRAIC CONCEPTS AND TECHNIQUES

6.6.1. Symbolic expression
- formulae
- change of subject

express basic arithmetic processes in letter symbols;
substitute numbers for words and letters in algebraic expressions (including formulae);
change the subject of a formula and substitute in formulae including those from other subjects (e.g. science);

6.6.2. Algebraic manipulation
- operations

- factors, multiples, HCF, LCM
- expansion
- factors

find and use common factors, common multiples, HCF and LCM;
expand expressions of the forms \( a(b + c) \) and \( (a + b)(c - d) \);

factorise expressions of the form
\[ ax - bx, \quad ax - bx + ay + by, \]
\[ ak^2 - 20, \quad a^2 + bx + c, \]
6.6.3. Indices
— laws of indices
use the following laws of indices (where \( m, n \) are integers other than zero):
\[
\begin{align*}
    a^m \times a^n &= a^{m+n} \\
    a^m \div a^n &= a^{m-n} \\
    a^n &= 1 \\
    (a^{-n})^{-1} &= a^m \\
    a^{\frac{m}{n}} &= \sqrt[n]{a} \\
    a^{-\frac{m}{n}} &= 1 / \sqrt[n]{a} \\
\end{align*}
\]
— squares/square roots
calculate squares and use factors to find square roots and cube roots;
— cubes/cube roots

6.6.4. Equations
— linear equations
solve the following:
simple linear equations (including those involving algebraic, fractional);
— simultaneous equations
simple linear simultaneous equations (by graphs, by substitution and by elimination);
— quadratic equations
quadratic equations of the form \( ax^2 + bx + c = 0 \) (by factorisation and by formula);

6.6.5. Logarithms
use basic ideas of the theory of logarithms;
use common logarithms in calculations (including finding powers and roots);

6.6.6. Inequalities
— signs
use the following in appropriate situations:
\[
\begin{align*}
    &=, \geq, <, \leq, >, < \\
\end{align*}
\]
— linear inequalities
solve linear inequalities of the form \( ax + b > c \) and
\( c < ax + b < d \) where \( a, b, c, d \) are rational;
— linear programming
represent inequalities and their solutions on a number line;
use simple linear programming methods to solve problems (unwanted regions to be shaded, with inequality boundaries shown by broken lines);

6.7 GEOMETRIC CONCEPTS AND TECHNIQUES

6.7.1. Points, lines and angles
use and interpret the terms:
point, line, parallel, perpendicular, right angle, acute, obtuse, reflex,
complementary, supplementary,
vertically opposite angles, angles at a point, angles on a straight line, transversal, allied or co-interior angles, corresponding angles, interior opposite angles, angles of elevation and depression.
— types of angles
— parallel lines
— angles of elevation and depression

6.7.2. Bearings
interpret and use three-figure bearings measured clockwise from north, i.e. from 000° to 360° and compass bearings (e.g. N 47° E)
<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Description</th>
</tr>
</thead>
</table>
| 6.7.3.  | Polygons | **Polygons**
|         | - triangles | use properties of triangles (including isosceles and equilateral), quadrilaterals (including kites, parallelograms, rectangles, rhombi, squares, trapezias);
|         | - quadrilaterals | use properties of triangles (including isosceles and equilateral), quadrilaterals (including kites, parallelograms, rectangles, rhombi, squares, trapezias);
|         | - n-sided polygons | regular and irregular n-sided polygons, and state the special names of n-sided polygons (up to \( n = 10 \)) ;
|         | - parallel lines and area | use the area property of triangles and parallelograms between the same parallels;
| 6.7.4.  | Circles | **Circles**
|         | use the properties of radius, diameter, chord, tangent, cyclic quadrilateral, angle subtended at the centre and on the circumference;
| 6.7.5.  | Similarity and Congruency | **Similarity and Congruency**
|         | identify similar and congruent figures and solve problems on similar and congruent triangles;
|         | solve problems on areas of similar plane figures and volumes and masses of similar solids;
| 6.7.6.  | Constructions | **Constructions**
|         | construct the following using ruler and compasses only: angle bisector, perpendicular bisector, angles of 30°, 45°, 60° and 90°;
|         | construct a perpendicular from a given point to a given line and through a given point on a given line;
|         | construct triangles, parallelograms and simple regular \( n \)-sided polygons, (protractors may be used where necessary);
|         | produce scale drawings using an appropriate/given scale;
| 6.7.7.  | Loci | **Loci**
|         | construct and use the locus (in two-dimensions) of a point equidistant from:
|         | a fixed point,
|         | two given points,
|         | a given straight line,
|         | two intersecting straight lines;
| 6.7.8.  | Symmetry | **Symmetry**
|         | recognise line symmetry in two dimensions; and properties of isosceles triangles, equilateral triangles, regular polygons, parallelograms and circles directly related to their symmetries;
|         | recognise rotational symmetry (including order of rotational symmetry) in two dimensions;
6.8.1. Pythagoras' theorem and trigonometrical ratios

apply Pythagoras' theorem, sine, cosine and tangent for acute angles to solve simple problems involving right-angled triangles in two-dimensions;

use and interpret sine, cosine and tangent of obtuse angles, use the sine and cosine rules for the solution of triangles (angles in either degrees/minutes or degrees to 1 decimal place);

solve three-dimensional problems involving the angle between a line and a plane.

6.8.2. Area of a triangle

use the formula Area = ½ ab sin C for the area of a triangle.

6.9 VECTORS AND MATRICES

6.9.1. Vectors in two dimensions

— translation and notation

represent a translation by a column vector and by a directed line segment and use the notation \( \vec{AB} \) or \( \vec{A} \to \vec{B} \);

— operations

add and subtract vectors and multiply by a scalar;

calculate the magnitude of a vector and use the notation \( |\vec{AB}| \) or \( |\vec{A}| \);

— position vectors

use position vectors;

— equal vectors

use equal vectors and parallel vectors;

— parallel vectors

6.9.2. Matrices

— dimension

use and interpret a matrix as a store of information and show familiarity with the idea of dimension of a matrix;

— operations

add and subtract matrices (where appropriate) and multiply by a scalar;

multiply matrices (of order 2 \( \times \) 2 or less) where appropriate;

— identity matrix

use the property of identity and zero matrix for 2 \( \times \) 2 matrices;

— determinant

find the determinant of a 2 \( \times \) 2 matrix and distinguish between singular and non-singular matrices;

— inverse matrix

find and use the inverse of a 2 \( \times \) 2 non-singular matrix (see also 6.10 on Transformations).

6.10 TRANSFORMATIONS

carry out the following transformations in the x-y plane:

— translation

translate (T) simple plane figures;

— reflection

reflect (M) simple plane figures in the axes and in any line;

— rotation and enlargement

rotate (R) and enlarge (E) about any point and using a rational scale factor;

— stretch

stretch (S).
6.11 STATISTICS AND PROBABILITY

6.11.1. Statistics

- collection and classification
- data representation
- measure of central tendency
- cumulative frequency

Statistics and data representation involve:
- Collect, classify and tabulate statistical data;
- Read, interpret, draw and make simple inferences from bar charts, pie charts, histograms and frequency tables/charts (see also 6.3.1);
- Calculate the mean, mode, median from given data and distinguish between the purposes for which they are used;
- Use an assumed mean where appropriate;
- Read and interpret data presented in classes and determine the modal class;
- Draw and use a frequency polygon and a cumulative frequency curve;

6.11.2. Probability

- terms
- experimental probability
- theoretical probability
- probability of single/combined events

Probability includes:
- Use the terms: random/certain/impossible event/trial/sample space/equally likely/mutually exclusive/independent events;
- Distinguish between experimental and theoretical probability;
- Solve simple problems involving the probability of a single event;
- Calculate the probability of and solve simple problems involving combined events (i.e. mutually exclusive and independent events) (use of tree diagrams is recommended).

7.0 SCHEME OF ASSESSMENT

<table>
<thead>
<tr>
<th>Weighting</th>
<th>PAPER 1</th>
<th>PAPER 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Paper</td>
<td>Approximately 30 short answer questions</td>
<td>Structured Questions Section A (6 compulsory questions), Section B (3 questions out of 6)</td>
</tr>
<tr>
<td>Time Allowed</td>
<td>2½ hours</td>
<td>2½ hours</td>
</tr>
</tbody>
</table>
Appendix B
A Brief Political and Educational History of Zimbabwe

The People

The following description of the people of Zimbabwe is simplified. It leaves out certain groups, for example, the San, Asians, and people of mixed race. As well, the labels "Shona," "Ndebele," and "European" are all encompassing terms which ignore ethnic and cultural diversity within these groups.

The Shona

About three-quarters of Zimbabwe’s people share similar languages and are collectively known as the Shona. They have been in the region between the Zambezi and Limpopo rivers since about 1000 AD. The ancestors of modern Shona were a settled people who kept livestock, smelted iron, and established trade contacts with the Arabs, the Swahili, and the Portuguese. The word Zimbabwe is derived from the Shona words “dzimba dza mabwe” which means “houses of stone.” The Shona developed a tradition of building stone wall enclosures, the ruins of which are found throughout the country. The best known of these is Great Zimbabwe which was the capital for a large region of southern Zimbabwe from the 13th to the 15th centuries.

The Ndebele

Mzilikazi, a Zulu general who became the first Ndebele king, fled South Africa in 1822 as a result of a dispute with the Zulu chief, Shaka, and established his followers at what is now known as Bulawayo in 1837. Descendants of Mzilikazi’s group are the present day Ndebele. Early Ndebele society continued the Zulu warrior tradition and was organised along military lines—all young men gave military service until about the age of thirty. Mzilikazi was succeeded by his son Lobengula who came into contact with missionaries and fortune-seekers from the diamond and gold finds in South Africa in the late 1800s.

The Europeans

In 1889 Cecil John Rhodes obtained a Royal Charter from the British government for the British South Africa Company partly as a result of concessions for mining which some of his men had negotiated with
Lobengula. Rhodes had become wealthy from South Africa’s gold and diamonds and wished to use his wealth to extend British rule in Africa. A “Pioneer Column” moved north from South Africa, establishing forts at Masvingo (Fort Victoria) and Harare (Fort Salisbury). The settlers staked out farms of up to 3000 acres under the Charter’s 1891 “mining regulations.” When expected mineral fortunes did not materialise the Company also settled Matabeleland. The Ndebele resisted the arrival of the settlers in 1893 but spears were no match for guns and Lobengula and his followers fled northwards. Lobengula reportedly died of smallpox in northwestern Matabeleland in 1984.

The Shona people rebelled in 1896 (The First Chimurenga); the leaders were captured and executed by the settlers. The word Chimurenga (murenga = resister) is used by Africans to describe both the 19th and 20th century liberation struggles against the European settlers.

**From Rhodes to Smith (1890 - 1965)**

The Royal Charter gave Rhodes’ company “permission” to administer the region. In 1923 the region became a British colony, partly in response to settler dissatisfaction with Company rule. British colonial policy was to encourage further European settlement in what was now southern Rhodesia. As the settlers continued to struggle for control of their own affairs their adversary shifted from the Company to the British government. By the 1950s and 1960s, however, the British government accepted the inevitability of African majority rule and was reluctant to grant independence to the white minority.

From 1952 to 1963 southern Rhodesia was part of a federation with northern Rhodesia and Nyasaland. The federation dissolved partly because the African population did not support it. Shortly afterwards, the two northern territories gained majority rule and became Zambia and Malawi respectively. Southern Rhodesia became Rhodesia.

Tension between Britain and the whites in Rhodesia, who were introducing more racist legislation, culminated in Ian Smith’s Rhodesian Front party declaring unilateral independence (UDI) in 1965. The British government responded by applying economic sanctions to the country.
African Resistance to Minority Rule

The introduction of a poll tax in 1894 by the Company forced Africans off their own land to work for wages in mines or on farms owned by Europeans. The 1930 Land Apportionment Act and subsequent land legislation (1941, 1969) geographically segregated the races with equal amounts of land being allocated to disproportionate numbers of Europeans and Africans. As well, the land best suited for cultivation was in European areas. Property and income qualifications governing the right to vote excluded Africans politically.

The African rebellions of 1893 and 1896 were quickly squelched. Subsequent African resistance changed over time from pressure groups which tried to persuade the white government to introduce socio-political reforms regarding land, wages, and racial discrimination to nationalist movements which increasingly favored confrontation over negotiation. The nationalist movements demanded majority rule, increased educational facilities and job opportunities, land reform, and better wages. In 1964, when their organisations were banned and their leaders detained, the nationalists established headquarters in Zambia and in Tanzania and embarked on military training with the help of Eastern bloc countries, Ethiopia, Algeria, and China. The main organisations at this time were the Zimbabwe African People's Union (ZAPU) and the Zimbabwe African National Union (ZANU). ZANU had split from ZAPU in 1963.

The Liberation War (1965 - 1980)

The armed struggle started in 1966 (The Second Chimurenga) as a reaction to UDI. ZAPU operated from Zambia on the western border. Their army, the Zimbabwean People's Revolutionary Army (ZIPRA), was trained by the Soviets. ZANU was based in Tanzania. Their army, the Zimbabwean African National Liberation Army (ZANLA) was trained by the Chinese. In 1974, with the collapse of Portuguese colonialism in Mozambique, ZANU moved its base of operations from Tanzania to Mozambique with the support of the socialist government there. The war in eastern Zimbabwe on the Mozambican border became highly politicised. The guerilla movements gained increased support among the peasants and more and more young people left the country to join the struggle. This intensification of guerilla activity in the 1970s pressured Smith to negotiate with nationalist leaders.
inside the country to form Zimbabwe-Rhodesia in 1979. Lack of international recognition for Zimbabwe-Rhodesia and continued fighting by the guerillas led to the Lancaster House negotiations later in 1979. ZAPU and ZANU attended as a united party called the “Patriotic Front” led jointly by Robert Mugabe (ZANU) and Joshua Nkomo (ZAPU). Other parties to the negotiations were the British and Abel Muzorewa’s internal government. Independence on 18 April, 1980 followed elections in February which were won by Robert Mugabe’s ZANU (PF) party.

Post-independence Zimbabwe

The new government pursued a policy of racial reconciliation and non-discrimination. Twenty of the 100 seats in the National Assembly were reserved for the white electorate for 7 years by the Lancaster House agreement. After 1987 whites continued to be elected and to hold Cabinet positions. Many whites had left the country during the war years; those who remained tended to either identify with the new order as “white Zimbabweans” or live in relative isolation as “Rhodies.”

Nkomo and Mugabe had campaigned for the election separately. Tension developed between ZAPU and ZANU(PF) in the early 1980s over “dissident” activity in Matabeleland but Mugabe and Nkomo signed a unity accord in 1987 and Nkomo (who had been expelled from government in 1981 over this trouble) returned to government as vice-president. Although the minority Ndebele sometimes feel disadvantaged by the Shona majority in government, relations between the two groups are amicable. Intermarriage is common, particularly in the Midlands and urban areas where contact is greatest.

The tribal trust lands (TTLs) were renamed communal lands. Land was traditionally seen as a communal right and was assigned to families by chiefs and headmen. Although customary law still operates in the communal lands, ultimate responsibility for them now rests with the State. By the end of 1985 about 36,000 peasant families were resettled on 2 million acres of under-utilised agricultural land, mostly land left vacant by whites who had left the country. Not all resettlement schemes were as successful as anticipated due to lack of skills, equipment, and infrastructure. After the 1985 elections ZANU(PF) passed a new Land Acquisition Act which gave the government first option to purchase any rural land for sale and to acquire any abandoned
land without compensation. New legislation in 1992, which further increased the government’s power to acquire land, was opposed by commercial farmers. Land redistribution has been one of the most complex and difficult issues to resolve in post-independent Zimbabwe.

Zimbabwe is an active member of the Commonwealth, the Organisation of African Unity (OAU), and regional organisations such as the Preferential Trade Area (PTA), and the Southern African Development Community (SADC). At independence, ZIPRA, ZANLA, and the Rhodesian forces were combined into one army which was trained by British defence personnel as part of the Lancaster House agreement. Defence was the highest budget item after education in the late 1980s. This was due to Zimbabwe’s involvement in a civil war in Mozambique in order to protect its road and rail access to the sea as well as continued South African destabilisation in Zimbabwe.

Mugabe’s government was initially committed to a socialist, egalitarian transformation of the economy. Drought in 1982-1984 and 1991-1992 badly affected the economy. Collapse of socialist economies elsewhere and Zimbabwe’s own economic difficulties resulted in the abandonment of socialist policies and acceptance of the free-market, capitalist economy inherited at independence. In practice whites and foreign capital still control the private sector. The black majority has not experienced the anticipated increase in overall living standards; instead a political and economic black elite has developed. In the 1990s Zimbabwe adopted the International Monetary Fund’s (IMF) Economic Structural Adjustment Program (ESAP), deregulating prices and cutting government spending.

**Educational Development in Rhodesia and Zimbabwe**

The earliest schools in Zimbabwe were established around 1870 by missionaries during Mzilikazi’s rule. Government schools were established by the settlers in the early 1900s. Many of these were boarding schools to meet the needs of those Europeans (whites) who were scattered on farms throughout the country. Schools were originally modeled on South African educational practice but when Rhodesia became a British colony in 1923 there was a movement towards the British educational system. This involves four years of secondary school to O (Ordinary)-level and a further two years to A (Advanced)-level. Small numbers of academic secondary schools were
established for Africans by missions, and later by the white government in the years following the Second World War. A multi-racial university, offering three year specialist degrees and post-graduate research and study, was founded in Harare (Salisbury) during the Federation years.

In Rhodesia, separate European and African education departments were under a single Ministry. White students proceeded automatically from free primary education to a comprehensive secondary school and, if academically competent, were assured of continuing to technical or university education. In contrast, African students had to pay school fees and to excel in examinations in order to continue their studies. In 1961 an M-level examination one year after O-level was introduced to the European schools so that white students could attend South African universities easily. Students planning to attend the local university or universities in Britain (which included all African students) still required A-level. In 1966 the Rhodesian Front government created the F2 schools, a type of junior secondary school for African pupils where about half of the time was spent in practical subjects in preparation for employment. These were perceived by the African community to be an inferior type of education and pupils only entered them if they did not get a place in the academic (government or mission) secondary schools.

In 1979 the European and African divisions of the Ministry were fused and the school system was re-organised along non-racial lines. Government schools were reclassified as either group A schools (the former schools of the European division) or group B schools (the former schools of the African division). Group A schools at that time required higher fees than the Group B schools and some of the Group A schools became short-lived “community schools.” Communities bought their schools from the government for a nominal sum and then enforced zoning regulations in an attempt to restrict their enrolments.

Since independence in 1980 the group A government schools are open to all. Private schools have been encouraged by the government, provided they maintain a 60% black enrolment. Grants have been provided to the established missionary secondary schools. Many schools have been built in the communal lands, resettlement areas, and commercial farming areas. From 1979 to 1986 primary enrolment went from 819,400 to 2,469,219 (a 201% increase) and secondary enrolment from 62,000 to 659,934 (a 964% increase).
In the rural areas Form One and Form Two classes were added to primary schools and these “upper top” schools later became rural day secondary schools administered by local district councils. New government schools have also been built in designated rural growth point areas.

Initially the ZANU(PF) government promoted “education with production” along lines developed in Tanzania and Mozambique where every pupil was required to study agriculture and to engage in manual work to contribute to the cost of running the school. Eight Zimbabwe Foundation for Production (ZIMFEP) model schools were established on farms just after independence. The ZIMFEP schools failed to have the intended impact (self-sufficiency and integration of theory with practice) on the rest of the school system though.

For many years during the colonial era the country had the highest pass rate in the world among countries that wrote the Cambridge O-level examinations. This was due in large part to the restricted and highly selected intake in African secondary schools. Since independence the pass rate has declined. Older established schools, particularly mission and private schools, have much higher pass rates than the recently built rural secondary schools. The schools with the higher pass rates attract the better students. As a result, schools in Zimbabwe have tended to become differentiated academically.

However, even with lower pass rates, the expansion of the education system has meant that there is a greater number of students obtaining high passes at O-level. Zimbabwe now has a serious problem with unemployed O-level graduates who cannot find employment or obtain places at institutions providing further education.

The expansion of the education system created an unprecedented demand for teachers. The government responded with several initiatives: recruitment of primary teachers for secondary schools and of under-educated people with no teacher training for both primary and secondary schools; increased enrolments in the ten conventional teachers’ colleges (seven primary and three secondary); introduction of the Zimbabwe Integrated Teacher Education Course (ZINTEC), a four year course for primary teachers in which students spent considerable time teaching in the schools; an agreement with Cuba to train 400 science teachers there; and the recruitment of expatriate teachers to teach secondary mathematics, science and English. A major consideration in recruitment of expatriate teachers was the ability to
communicate effectively in the language of instruction, English; hence many expatriates were from Britain, Canada, and Australia. By 1984 there were 1,333 expatriate teachers in Zimbabwe out of a total teaching force of 14,175 teachers. Foreign recruitment in Zimbabwe was a temporary policy adopted to resolve the immediate problem; by 1993 there were far fewer expatriate teachers in the country because the education system had successfully produced more qualified teachers.

Bibliography


Appendix C
Glossary of Terms

A-level: two years of secondary school after O-level leading to a three year university degree. In Zimbabwe not all of the schools offer A-level as well as O-level.

Core science: locally developed science curriculum at O-level organised on the themes: energy, agriculture, industry, health, structures. It was intended that most students do the core and academic students proceeding to further study do an extended part of the syllabus. In fact, many students do chemistry, physics, and biology as separate subjects in preparation for A-level if the school offers them.

Education officer: Ministry representative usually responsible for a particular subject area. Each province has a regional office of the Ministry.

ESAP (Economic Structural Adjustment Program): economic measures introduced by the government in the early 1990s. Cuts in government spending have had a significant impact on education.

Expatriate (expat): foreign worker on short-term contract recruited by governments in response to local shortage of expertise. Zimbabwe employed many expatriate teachers in the 1980s, mainly at senior secondary level in English, mathematics, and science.

F1 schools (as opposed to F2 schools): before independence, government schools for the most academically competent African students. Several of these were established after the Second World War in response to demand for education and in an attempt to control African education.

F2 schools: two year junior secondary schools with a vocational bias for African children introduced by the Rhodesian Front government of Ian Smith in 1966. These were not popular at the time with the African community.

Government schools: schools established pre-independence by the Rhodesian government, and post-independence by the Zimbabwean government. The latter are mostly located in high density areas.

Group A schools: the former comprehensive schools of the European division. They were reclassified as group A schools in the transition period.
just before independence. These schools are now attended by all races and have the best facilities, especially for sports.

**Group B schools**: government schools in the former African division, also reclassified in 1979. In the 1970s and 1980s these were over-crowded in the urban areas, first because of the influx of refugees from the war-torn rural areas then because of increased access. To cope the schools introduced “hot-seating” or double sessioning where one group of students came in the morning and another in the afternoon.

**GTC (Gweru Teachers' College)**: before independence, GTC was the only teachers college training African secondary school teachers. Teachers’ colleges in Zimbabwe are affiliated with the University of Zimbabwe through the Associated College Centre in the Faculty of Education. Students entering with O-level pursued a three or four year program, completing mathematics courses equivalent to A-level (first and second year university in North America). More recently, students entering with A-level complete a two year program.

**High density area** (township): formerly African part of urban areas. High density areas are more crowded with poorer housing than in low density areas.

**Low density area**: formerly European part of urban areas. Now middle-class Zimbabweans of all races live in the low density areas which have spacious houses and gardens.

**Midlands province**: one of eight administrative regions of the country (West, Central, and East Mashonaland, Manicaland, masvingo, North and South Matabeleland). The project school and GTC were both in Midlands province.

**Mission schools**: schools established by missionaries, usually in rural areas. Mission schools are now supported by the government. They have good academic reputations and attract the better African students. The first secondary school for Africans in Rhodesia was established at St. Augustine’s Mission in 1939.

**Moto magazine**: published by Mambo Press which is owned by the Gweru Diocese of the Roman Catholic Church. Moto magazine challenged the
Rhodesian government over its policies and still debates controversial issues. It often contains letters and articles about education.

Ndebele: people occupying the south and western part of Zimbabwe (as well as parts of South Africa) and their language. The Ndebele are descendents of Mzilikazi and Lobengula.

O-level: four years of secondary school (Forms One to Four). Passes in five O-level subjects is considered to be secondary completion and is required for entry into technical schools, teachers' colleges, and other training programs.

Primary schools: grades one to seven. The first years of primary school are often referred to as infant school.

Private schools: privately-financed schools charging high fees. In practice, these are the schools in present day Zimbabwe which are the most multi-racial.

Records of marks: list of marks kept by a teacher.

Regional office: local administrative (provincial) centre for government Ministries.

Rural schools: schools outside of urban areas. Rural schools are built and managed by local district councils with the help of their communities. They have difficulty attracting well-qualified teachers because of lack of amenities and housing.

SADCC (Southern Africa Development Coordination Conference): economic group of countries in southern Africa (Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe). It has now become SADC (Southern Africa Development Community). Each country has responsibility for a specific economic sector within SADC, for example, Zimbabwe is responsible for agriculture and regional food security.

Schemes of work: planning book kept by teachers. Schemes of work include comments on how the work progresses and are checked each term by administrators.

School syllabus: interpretation of the national syllabus prepared by the head of department in a given school. The school syllabus outlines the work to be covered each term.
Shona: people occupying the central, north, and eastern parts of Zimbabwe (and parts of Mozambique) and their language.

Social Dimension Fund: introduced to offset the hardships of ESAP. The fees of many of the students at the project school were being paid through the Social Dimension Fund.

Teacher in Zimbabwe: magazine published by Zimbabwe Publishing House on behalf of the Ministry of Education and Culture and distributed to schools free of charge. It carries letters and articles from teachers.

Township: equivalent to high density areas.

Upper-top schools: primary schools in the rural areas offering Form One and Form Two on their premises until buildings for a secondary school could be constructed. The “upper-tops” were created just after independence.

WUSC (World University Service of Canada): development organisation recruiting teachers for Zimbabwe. WUSC is also active in fund-raising and awareness activities in Canada and work with international students at Canadian universities.

ZIMFEP (Zimbabwe Foundation for Education with Production): schools established on farms right after independence. ZIMFEP schools were based on the model of education practised in refugee and guerilla camps during the war which integrated theory and practice.


ZJC (Zimbabwe Junior Certificate): credential obtained on passing examinations at the end of Form Two.
Appendix D
Permission to Do Research

DI: Approval of Application to Research in Schools from the Ministry of Education and Culture

Reference: C/426/10

MINISTRY OF EDUCATION AND CULTURE
P.O. Box 9622
Causeway
Zimbabwe

17 October 1991

Ms. Jean Atkinson
6010 Grant Street
Burnaby, B.C.
V5E 2K5 Canada

Dear Sir/Madam,

APPROVAL OF APPLICATION TO RESEARCH IN SCHOOLS

Your application to carry out research, in institutions under the Ministry’s jurisdiction, into the preparation and evaluation of secondary mathematics materials has been approved.

Please contact the Regional Director of the region(s) where the school(s) you wish to visit is/are located and produce this letter.

The Ministry would be grateful for a copy of your completed research report, which may contain information useful to the development of education in Zimbabwe.

L. A. Mortimer
for Secretary for Education and Culture
D2: Certificate of Registration from the Zimbabwe Research Council

FORM RA.3

Research Act, Section 26A.

RESEARCH ACT, 1986
RESEARCH COUNCIL OF ZIMBABWE
CERTIFICATE OF REGISTRATION

No 01732

Name ................................................................. M.J. ATKINSON .................................................................

Nationality: CANADA Passport No: YW 137583

Institution of Affiliation in Zimbabwe: MINISTRY OF PRIMARY AND SECONDARY EDUCATION
P.O. BOX 8022
CAUSEWAY, HARARE.

Residential Address in Zimbabwe:

................................................................. .................................................................

................................................................. .................................................................

The bearer has been registered to conduct research in the field of MATHEMATICS EDUCATION

in terms of section 26A of the Research Act, 1986.

Expire date: 31 DECEMBER, 1993

Signature of Bearer

Date: 9 MARCH 1992

This receipt is not valid unless it is stamped.

209
D3: Permission to Carry Out Research in One of the High-density Schools in Midlands Province

13 May 1993

Ms Jean Atkinson
C/o WUSC
P.O. Box 1390
Harare
Zimbabwe

RE: APPLICATION FOR PERMISSION TO CARRY OUT RESEARCH IN SCHOOLS

Your application dated 6 May, 1993 concerning the above refers.

Permission is hereby granted for you to carry out your research in one of the high-density schools in the Midlands Region.

As your research will be in one of the schools in Midlands Region, we would ask you to approach the Regional Director of Midlands Region with a copy of this letter before you carry out your research. Could you also please give us your research instruments? Finally, the Ministry of Education and Culture would be grateful for a copy of your completed research project.

J.G. Mugadzaweta
for: SECRETARY FOR EDUCATION AND CULTURE

B/BT

RECEIVED
18 MAY 1993
wnt1 university service & record

210
Appendix E
List of Resources

Teaching Aids

attribute blocks
base ten blocks
circular clear-view geoboard
clear plastic geometric volume set
clear view geoboard
cubes (2 cm)
Cuisenaire colour cubes
density blocks
density cylinders
dice
dominoes
equilateral prism
fiberglass measuring tapes
geoboards
geometric shapes template
large 3-D shapes
magnetic counting game and abacus
micrometer
Mira-Math Activities for High School Geometry
Miras
mirror (15 cm x 20 cm)
pattern blocks
pentominoes
plastic mirrors
playing cards
protractors
Reflection Activities Using a Mirror
rubber bands
rulers
safety compass (17.5 cm)
safety compasses
scissors

one set
one set
two
one set
two
pkg 100
one set
one set
one set
ten pair
six sets
one
ten
fifteen
one set
one
one set
one
one box
twenty
one
ten
five pair
Teaching Aids (cont’d)

spring scales (250g, 500g, 1000g, 2000g) four
tanagrams two sets
TI 108 solar standard calculators fifteen
trundle wheel one
unbreakable concave/convex mirrors ten
Using Cuisenaire rods: a photo-text guide for teachers one

Books


Appendix F
Student Feedback

F1: Class Discussions

We asked the students in 1E, 2A, 2C, 3B, 3D, 3E and 4B (Phiri's classes
and my classes): What would help you to learn better? What are some of your
problems? Phiri did most of the talking and I took notes. Discussions with 2A,
3B, 3D, and 4B took place before the August break; we met with the other
forms after the break.

F2: Questions to Guide the Written Responses

We reminded the children of the group discussions and explained that
we wanted to explore further with them some of the issues that had come up
as well as obtain feedback from them about other aspects of my project. Our
questions differed slightly with each class.

Teaching Aids and Activities

What did you think about the use of teaching aids, for example ... (give
examples particular to each class). Do they help you to learn? Why or why
not?

Group-work

What did you think about working in groups? Does it help you to
learn? Why or why not? Which groups are best—mixed groups or
ability/achievement groups? What are some of the difficulties?

Marking, exercise books, and tests

What do you think about marking your own work? Does the teacher
have to mark all your work? (Must you do one exercise every day? What is
the purpose of your exercise book? Should pupils have access to answers?
Were the Friday tests a good idea? How do you feel when you get low marks?
Do you do okay in class, but poorly on tests? If so, why? Do you look carefully,
learn from the teachers' marking, from making corrections?)
Mathematics Club

Did you attend the maths club? Is a mathematics club a good idea? Why or why not? What should happen there?

Communication

Do you answer or ask questions in class? Why or why not? (My classes only: Do you understand me? Do you know what to do?

Syllabus Coverage (2A, 2D, 2C and 4B only)

Is it better to take time or cover all topics quickly? (My classes only: We took more time on some units. Do you feel disadvantaged?

Difficulties (2A, 2C and 4B only)

How do you think you will do in the examination? Why? If you think you will not pass, what are the reasons? What could have helped?
Prefacing Remarks

The purpose of this interview is to find out more about you and what you think about teaching mathematics. In particular, what would help you to teach mathematics better and what has been your experience teaching the 1991 Zimbabwe syllabus? The information may be reported, to the Ministry and in my thesis, but not using your name. I would like you to listen to the tape when we are finished; please feel free to delete or correct anything you said. Hopefully, talking about these things will be a useful starting point for developing teaching materials to support the syllabus.

Perhaps we can begin by talking about your training and experience.

Teacher Background

Q1: Tell me about yourself; in particular, your educational and professional background.

Q2: Describe your preparation for teaching mathematics. In your view was this training adequate? Could it have been better? If so, how?

Q3: Have you ever done any in-service education? If so, what was it like?

Let’s talk about what it is like to teach mathematics in this school.

Context: School and Ministry

Q1: What do you perceive to be the expectations of the Ministry and the school regarding the teaching of mathematics? How do these expectations affect your day-to-day activity?

Q2: What do you think should be done to improve the teaching of mathematics in this school? in Zimbabwe? What would be ideal?

Can we get more specific about your own teaching?

Pedagogy

Q1: What do you feel most influences how and what you teach?

(Probes: syllabus, school syllabus, text, other curriculum materials, other teachers, pupil interest, personal interests, examinations, how you were taught, how the pupils like to learn ... )
Q2: What works well in your classes (re teaching mathematics?)
Q3: What difficulties do you encounter in teaching mathematics? Do you feel constrained in your ability to teach the way you would like to? If so, what are some of the constraints?
Q4: What do you like about what you are doing?
Q5: What are the pupils like to teach? How do they feel about learning mathematics? Are there noticeable differences in attitude and/or achievement between boys and girls?

A lot of things influence what happens in classrooms: the syllabus, examinations, the textbook, other resource materials, the teacher, the pupils ... For purposes of this interview I am calling what actually happens in classrooms the "curriculum." Can we explore some of these factors?

Curriculum
Q1: What influence do examinations (ZJC, O-level) have on your teaching?
Q2: How do you assess and evaluate your students?
Q3: What do you think of the 1991 O-level syllabus?
Q4: Did you do any preparation to teach this syllabus? If so, what did you do? How does it differ from the previous syllabus? Do you do anything differently? If so, what?
Q5: Have you had any direction or assistance in implementing this syllabus? If yes, tell me about it. If no, should there have been? Would you have participated in it?
Q6: What kind of support, if any, do you feel you need?
Q7: What do you think of the textbooks? How do you use them?
Q8: Do you use any other resources?
Q9: Would additional curriculum materials help to teach this syllabus? If so, what sort of materials would be most useful?

The 1991 syllabus suggests specific teaching methods. I am interested in what you think about these.
Syllabus Methodology

Q1: Are you familiar with the methodology (approaches to teaching) suggested in the 1991 syllabus? Did your training prepare you for these?

It suggests the following (refer to syllabus; points summarised below):

- concepts be developed from concrete to abstract (5.1);
- principles be learnt through activity-based or guided discovery (5.2);
- skills be learnt after concepts and principles (5.3);
- human element in mathematics be emphasised (5.4);
  (What does this mean to you? There is a lot of interest in ethnomathematics these days. Should we be concerned with this?)
- skills taught in other subjects reinforced (5.5);
- pupils should check and criticise their own and other's work (5.6);
- group-work (5.7);
- problem-solving taught as a skill; non-routine problems (5.8);
- project work—identify problems in the environment (5.9).

Q: Are these suggestions reasonable? Why or why not? What do you address or not address in your own teaching now? What would you like to do more of?

Conclusion

Q1: Is there anything I should have asked that I did not?
Q2: Do you have anything you would like to add?
Q3: Is there anything you would like to ask me about my project?
Prefacing Remarks

My thesis is about the implementation of the 1991 mathematics syllabus, in particular, the nine methodology statements. Are these suggestions reasonable? If so, how can teachers be helped to implement them? If they are not reasonable, why not? Should they be included in a revised syllabus?

I am interested in your thoughts about these statements.

I would also like you to comment on some issues and concerns which have arisen for me over the last eight months. Some are related to the methodology statements; some are of a more general nature.

Teaching Methodology

Please refer to the syllabus.

5.1 I think teaching aids are concrete situations.

Q1: Did you find any of the teaching aids I brought useful? If so, which? How did you use them? Were there factors which prevented you from using them (eg. accessibility)?

5.2 You told me activity-based learning was time-consuming. The pupils seemed to enjoy doing activities and they said this helped them learn. Although there is not much evidence that this translated into better performance, it seemed worthwhile. But it was time-consuming.

Q2: How is it possible to get more time for teaching and learning?

What happened to the idea of a core syllabus?

5.3 Teachers seem to mark most or all of the work children do.

Q3: Why? Are there other ways of providing feedback to pupils?

I found it difficult to mark and prepare lessons. The children complained that I did not mark all their work.

Q4: How do you handle the marking load?

5.7 The pupils like group-work because they could “share ideas.” But they complained about noise and that all did not participate. I think they were uncomfortable with the noise level even when it seemed to me the class was going just fine.

Q5: Do you think I am right? Is this a factor in implementing activity-based learning or group-work?
Language

The children found it difficult to understand me, especially the Form Ones.

Q: How much is language a factor in the children’s learning difficulties?

Assessment and Curriculum

Q1: Why do they do so poorly on tests? Should tests be adapted to the class or should they always be ZJC/O-level standard?

There were some changes introduced this year. For example, two top classes were created in Form One; the other classes are just mixed. The two best Form Three classes were separated into a science stream and an arts stream. Some were given fewer subjects so have more preparation periods.

Q2: Will these things help? Why or why not?

Q3: What do the parents of Kwelo expect the school to do for their children? Will they support the above changes? Would they support an alternative curriculum in mathematics?

Conclusion

Q1: Do you have any comments about the workshop?

Q2: If you were consulted by the national panel what advice would you give them?
Appendix H
The Isometry Game (Mathematics Club and Teacher Workshop)


The game involves a knowledge of the isometric transformations: reflections, rotations, and translations.

The Game Board
Players take turns to move a triangular piece on the game board (Figure H1) according to given transformations. The transformations are described on playing cards. Players gain points according to the colour of the triangle on which the piece lands when it is moved according to the transformation on the card that is played. The points for each colour are as follows:

- Red—1 point
- Blue—2 points
- Yellow—3 points
- Green—4 points
- Purple—5 points
- Orange—6 points

The Playing Cards
Each card describes a transformation. The cards (Figure H2) are of two kinds: cards which give the exact details of a transformation and cards which give a player some freedom of choice in deciding the details of the transformation (jokers). There are 42 cards: three each of rotations with the centre of rotation at the origin and two each of rotations with the centre of rotation at the right angle of the triangle; three each of reflections; seven translation jokers, and four each of the rotation and reflection jokers.

Rules of Play
The game can be played by two, three, or four players (or teams of players). The object of the game is to score as many points as possible. The winner is the player with the most points when the cards are used up and no one can play. The following instructions are written to an individual player.

1. Shuffle the cards and deal five cards to each player. Place the remaining cards face down on the table.
2. When it is your turn, attempt to move the triangular piece from where it is to another triangle on the board. You can only make moves corresponding to the the cards you hold in your hand. The move can correspond to one card or to a combination of cards. In the case of a
combination the intermediate positions of the piece need not correspond to a marked triangle.

3. Place your used card or cards on a throw-away pile face-up beside the unused pile.

4. After playing, take a card or cards from the top of the unused pack to top up the number of cards in your hand to five.

5. If you cannot make a move, or if you prefer not to move, you may throw away one card and pick up a new one.

6. When using a joker card, you must announce the details of the move (for example, the equation of the mirror line) before moving the piece.

At any point in the game a player who thinks that a move does not correspond to the card or cards played may challenge the play. If the move is incorrect the triangle must be returned to its former position and the player misses his/her turn. If desired, play can be continued when the cards are used up by reshuffling the throw-away pile and drawing from it.
Figure H1
The Game Board for Isometry
Figure H2 The Playing Cards for Isometry

<table>
<thead>
<tr>
<th>REFLECTION</th>
<th>REFLECTION</th>
<th>REFLECTION</th>
<th>REFLECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mirror Line:</td>
<td>Mirror Line:</td>
<td>Mirror Line:</td>
<td>Mirror Line:</td>
</tr>
<tr>
<td>$x = 0$</td>
<td>$y = 0$</td>
<td>$y = x$</td>
<td>$y = -x$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ROTATION</th>
<th>ROTATION</th>
<th>ROTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre of Rotation: Origin</td>
<td>Centre of Rotation: Origin</td>
<td>Centre of Rotation: Origin</td>
</tr>
<tr>
<td>Angle of Rotation: $+90^\circ$</td>
<td>Angle of Rotation: $-90^\circ$</td>
<td>Angle of Rotation: $180^\circ$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ROTATION</th>
<th>ROTATION</th>
<th>ROTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre of Rotation: Right angle</td>
<td>Centre of Rotation: Right angle</td>
<td>Centre of Rotation: Right angle</td>
</tr>
<tr>
<td>Angle of Rotation: $+90^\circ$</td>
<td>Angle of Rotation: $-90^\circ$</td>
<td>Angle of Rotation: $180^\circ$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>JOKER</th>
<th>JOKER</th>
<th>JOKER</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSLATION</td>
<td>ROTATION</td>
<td>REFLECTION</td>
</tr>
<tr>
<td>Centre of Rotation:</td>
<td>Angle of Rotation:</td>
<td>Mirror Line:</td>
</tr>
</tbody>
</table>
Appendix I
Sample Lessons

These are included to give some indication of the nature of the classroom activities that the pupils engaged in during the project. Brief descriptions of each lesson below are followed by samples of students' work.

Lesson 11: Area of a Leaf (Form One)

This is an activity similar to an activity in the Year One ZimSci study guide. Working in pairs, pupils traced the outline of as many leaves as would fit onto a piece of squared paper and estimated the area of each by counting squares. They then found the average area of a leaf.

Lesson 12: Zimbabwe Bird (Form Two)

The purpose of this exercise was to provide practice plotting points in preparation for work on graphing functions. The pupils plotted sets of coordinates, each set corresponding to a line. It was very important to follow the directions exactly. The final result is not obvious until most of the points are plotted; children, of course, are familiar with the Zimbabwe bird.

Lesson 13: Height of a Flagpole (Form Three)

We asked pupils to suggest ways to find the height of the school's flagpole as well as the length of the rope. Following discussion of the task they prepared a diagram in class in their exercise books. After being shown how to use the trundle wheel and clinometer outside, they measured the distances and angles shown on their diagrams, working in small groups. As soon as they had made their measurements they returned to the classroom to calculate the required angles, lengths, and heights using the appropriate trigonometric ratios.

Lesson 14: Introducing Matrices Using Football Results (Form Four)

I used local football results to introduce the concept of a matrix and operations with matrices. I distributed among the class results from a local paper of sixteen teams in the National Soccer League. The class was asked to identify their favorite four teams. Each student then wrote down a matrix giving the wins, draws, and losses for those four teams from the data. This
was followed by class discussion about how matrices could be used to represent information.

The next day I brought results from the following week's paper and gave the students the task to write and interpret a matrix representing what had happened to our teams over the course of the week. This was followed by class discussion about addition and subtraction of matrices. The students then wrote a matrix representing the number of points each of our four teams had as of this week: if a win = 2, a draw = 1, and a loss = 0. After they did the calculations we discussed a definition for multiplication of matrices.
Figure II
Area of a Leaf

Joanne Narsi
Flora Thaimu
Figure I2
The Zimbabwe Bird
The length of a pole: \( \tan 38^\circ = \frac{\text{opp}}{\text{adj}} \)

5 \( \tan 38^\circ \) = opp

5 \( x \frac{1}{0.7813} \) = opp

5.9065 = opp, correct to 3 sig fig

(b) The length of opp side AC = 3.91 m

(c) The length of the whole pole AD = 3.91 + 1.65 m

\( \frac{3.91}{2.68} \) = hyp

3.68 \( \cos 25^\circ \) = opp

3.68 \( x \) 1.9573 = 7.202, correct to 3 sig fig

(d) The length of \( \text{hyp AE (y)} = 7.20 \) m

(2) Hyperbolic (RE)

\( a^2 = 7.20^2 + 3.68^2 \)

\( a^2 = 51.84 + 13.54 \)

\( a^2 = 65.38 \)

\( a = \sqrt{65.38} \)

\( a = 8.083 \) m, correct to 5 sig fig
Figure 14
Matrices from Football Results

<table>
<thead>
<tr>
<th>Team</th>
<th>W</th>
<th>D</th>
<th>L</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rhinos</td>
<td>13</td>
<td>6</td>
<td>3</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>Chapungu</td>
<td>12</td>
<td>7</td>
<td>1</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>CAPS United</td>
<td>11</td>
<td>4</td>
<td>6</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Eiffel Flats</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>Darryn Textiles</td>
<td>9</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Highlanders</td>
<td>8</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Dynamos</td>
<td>11</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Mhagura</td>
<td>12</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Black Aces</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Shu-Shine</td>
<td>11</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Zimbabwe Saints</td>
<td>11</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Wankie</td>
<td>10</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Tanganda</td>
<td>11</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Fire Batteries</td>
<td>11</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Ziscosteel</td>
<td>12</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Black Mambas</td>
<td>10</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>12</td>
</tr>
</tbody>
</table>

**Subtraction of matrices**

\[
\begin{pmatrix}
7 & 3 \\
17 & 4 \\
6 & 21
\end{pmatrix} - \begin{pmatrix}
3 & 6 \\
15 & 4 \\
5 & 61
\end{pmatrix} = \begin{pmatrix}
0 & 10 \\
0 & 20 \\
100 & 100
\end{pmatrix}
\]

**Multiplication of matrices**

\[
\begin{pmatrix}
3 & 7 & 3 \\
17 & 4 \\
6 & 21
\end{pmatrix} \cdot \begin{pmatrix}
2 \\
10
\end{pmatrix} = \begin{pmatrix}
13 \\
9 \\
16
\end{pmatrix}
\]

**Matrix representation**

- **Dynamos drew (tied) one game**
- **Tanganda tied two games**
- **Highlanders and CAPS United both won the game they played**

<table>
<thead>
<tr>
<th>Team</th>
<th>W</th>
<th>D</th>
<th>L</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPS United</td>
<td>12</td>
<td>5</td>
<td>6</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>Eiffel Flats</td>
<td>12</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>22</td>
</tr>
<tr>
<td>Chapungu</td>
<td>13</td>
<td>7</td>
<td>2</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>Black Rhinos</td>
<td>13</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Highlanders</td>
<td>13</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Mhagura</td>
<td>12</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Zimbabwe Saints</td>
<td>12</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Dynamos</td>
<td>13</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Black Mambas</td>
<td>11</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>Wankie</td>
<td>11</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Shu-Shine</td>
<td>12</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Tanganda</td>
<td>12</td>
<td>1</td>
<td>7</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Black Aces</td>
<td>11</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Fire Batteries</td>
<td>11</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Ziscosteel</td>
<td>13</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>12</td>
</tr>
</tbody>
</table>

229