Identifying Relevant Factors in Implementing a Chemistry Curriculum in Botswana

Lesego Tawana

Identifying Relevant Factors in Implementing a Chemistry Curriculum in Botswana

Lesego Tawana

A thesis submitted to the Faculty of Science, University of Witwatersrand, Johannesburg in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

April 2009

DECLARATION

I declare that this thesis is my own unaided work. It is being submitted for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted for any other degree anywhere else.

Signed ----------

Date ----------

DEDICATIONS

To my father, Tawana Mudongo

and

late grandmother, Machangana Mudongo

These are the people who sacrificed to give me a great education, and in the process passed on a love of knowledge and learning!

ABSTRACT

A general concern in science education is that change in the curriculum has had little impact on the classroom practice. Following the introduction of a new curriculum called the Botswana Government Certificate in Secondary Education (BGCSE) curriculum in Botswana senior secondary schools, this study set out to investigate issues relating to implementation of the proposed curriculum, that is, mapping teaching effectiveness intended to improve students' learning of chemistry compared with teaching during the old curriculum. This thesis reports the extent to which some chemistry teachers in Botswana senior secondary schools are implementing classroom methodologies that focus on learner-centred and hands-on activities.

This investigation involved working with eleven chemistry teachers in four secondary schools in Botswana. The case study research methodology included observations and semi-structured interviews. The sub-constructs from Rogan and Grayson's (2003) theory were used to guide data collection as well as analysis and interpretation of data. From the categories, it was possible to identify level of operation for the schools as well as the Zone of Feasible Implementation (ZFI) which spelt possible routes for interventions in individual schools.

There were common areas observed about the teachers and the schools, in that they

- All possessed the right qualifications to teach chemistry at senior school level.
- All were relatively young in the teaching field
- According to Rogan and Grayson's (2003) scale, the teachers are operating at a very low level in the science practical and contextualisation dimensions.
- Classroom dimensions were characterized by patches of rich interactions for most teachers. These were evidenced by some teaching interactions at level 3 on Rogan and Grayson's operational levels. Some teachers' lesson activities were more interactive in that there were presentations that encouraged the use of various communication skills. Learners presented organised information to support their positions, showing there had been a search for information before presentations. The other teachers limited involvement by learners, as their focus was on articulating the content.

- Otherwise teachers were generally operating at lower levels in Rogan and Grayson's (2003) scale. This is a clear indication that to some extent the teachers are not doing much in implementing the teaching ideas intended by the new curriculum. Mind and hands-on activities are still limited. Though teachers possess the right qualifications, there seems to be little desire to try new things.

According to the operational levels on classroom interaction, practical work and contextualisation, it was found that teachers generally operated moderately on Rogan and Grayson' scale. Though interviews results showed that teachers saw the need to have practical work as a way to actively engage learners, classroom observations showed that it was not a favoured method. Classroom observations revealed that the lecture method was still the favoured approach. Some learner-engaging activities in the form of group discussions, group experiments and demonstrations were practiced. Contextualizing of science was still generally low in all schools.

The study also looked at the construct of capacity to support innovation. The three sub-constructs which were investigated in this study were physical resources, teacher factors and ecology and management systems. These factors had a great impact on how the sub-construct on profile of implementation panned out. The three factors were found to be higher on the Rogan and Grayson's (2003) scale than the profile of implementation. This was found to be linked with a great deal of improvement of infrastructure by the Botswana government soon after the curriculum implementation e.g. science related facilities (laboratories, apparatus, chemicals) and teacher qualifications. Though this was the case, it was found out that classroom implementation was not as inflated as the resources on ground seemed to suggest. Several influential factors were found to be linked to the unfolding of a curriculum inside the classroom such as departmental contexts. The contexts were found to relate closely with the nature of communities that existed in science departments, which were linked to how teachers were distributed within departments.

ACKNOWLEDGEMENTS

The author gratefully acknowledges those whose support, assistance and suggestions have made the completion of this project possible.

First the ***teachers*** and ***students*** of Domboshaba, Lesedi, Maru and Tagala senior secondary schools who are the main focus of the study that forms a major part of this thesis. I want to thank them for accepting me in their school communities, for their support and friendship.

My thanks go to many colleagues at ***Marang*** (Centre for Mathematics and Science Education, Wits), who listened to seminar presentations and discussed ideas, read drafts and papers and in many other ways supported the development of my ideas.

I would particularly like to acknowledge the support of Professor Marissa Rollnick, Dr Gail Green and my fellow doctoral students who provided invaluable feedback and advice in the development of the text of my doctoral thesis. My doctoral supervisors, Professor Marissa Rollnick and Dr Gail Green contributed enormously to my development over the years and I hope we will have the opportunity to continue to work together. The many hours we spent in Marissa's office have been a pleasure and an education.

I also thank the ***University of Botswana*** for granting me training leave and sponsoring me through my years of study.

I am profoundly grateful for the support, love and prayers of everyone at the Potters' House (Melville) and CFC (Gaborone)…& especially the following: Pastor Bart Kooijker; R. Botha *AND* Dingane and Family ; 'The Millers' & Isaac M.

My grateful thanks also go to:

- '*Shumba-Tema*' for their moral support…!
- My colleagues at DMSE, UB
- My daughter Unami who gave me hugs when I needed them most.
- And finally my wife, partner and best friend Boi, who supported me in more ways than I can possible name. Her love carried me along when my confidence was shaky.

DECLARATION iii
DEDICATIONS iv
ABSTRACT v
ACKNOWLEDGEMENTS vii
LIST OF TABLES xiii
LIST OF FIGURES xiv
LIST OF APPENDICES xv
KEYWORDS xv
CHAPTER 1 INTRODUCTION 1
Introduction 1
1.1 The Problem 2
1.2 Rationale of the Study 2
1.3 Aims of the Study 3
1.4 Purpose of the Study 4
1.5 Research Questions 4
1.6 Significance of the Study 5
CHAPTER 2 THE BOTSWANA CURRICULUM 6
2.1 Botswana's Curriculum History 6
2.1.1 Primary School Education 7
2.1.2 Post Primary Education 9
2.2 The Cambridge Overseas School Certificate (COSC) Curriculum 10
2.3 The New BGCSE Curriculum 12
2.4 The Localisation Requirements (Organisation) 14
2.4.1 Development of the New Chemistry Curriculum 14
2.4.2 Organisation of the Chemistry Curriculum 15
2.4.3 Science for All 16
2.5 The Chemistry Curriculum 17
2.6 The Current Education System 18
2.6.1 Drop-Outs 20
2.6.2 Progression to Senior Secondary Education 20
2.7 Innovative Teaching 22
2.7.1 The Recommended Teaching Methods 22
2.7.2 Challenges 22
2.8 The Teachers 23
2.9 General Student Discipline 26
2.10 Summary 27
CHAPTER 3 LITERATURE REVIEW 28
Introduction 28
3.1 The Theoretical Framework 28
3.1.1 Constructs of the Theory of Curriculum Implementation 29
3.1.2 The Zone of Feasible Implementation 33
3.1.3 Situated Perspectives 38
3.1.4 Amalgamating Rogan and Grayson's Three Constructs 39
3.2 Other Literature Relevant to this Study 43
3.2.1 Other Studies on Curriculum Implementation 43
3.2.2 Studies of Curriculum Reform 46
3.3 Studies of Teaching-Learning Relevant to this Study 50
3.3.1 Science and Contexts 50
3.3.2 Practical Work 53

3.3.3 Teaching and Assessment in Practical Work....54
3.4 Teacher Related Research....55
3.4.1 Subject Matter Knowledge (SMK)....56
3.4.2 Pedagogical Content Knowledge (PCK)....58
3.4.3 Teacher Change....60
3.4.4 Change in Classroom Practice....61
3.5 Summary of Sections....63
CHAPTER 4 METHODOLOGY....64
4.1 Case Studies in Science Education....64
4.1.1 Background to Case Studies....64
4.1.2 Identifying the Boundaries....66
4.1.3 Different Types of Case Study....69
4.1.4 Case Study Overview....71
4.2 Case Study Designs....72
4.2.1 Data Collection....72
4.2.2 Ethical Considerations....73
4.2.3 Validating Case Studies....74
4.3 Development of Instruments....77
4.4 The Sample and Description of Instruments....79
4.4.1 School Descriptions....79
4.4.2 Gaining Access....81
4.5 Data Collection Procedures....81
4.5.1 Direct Observations....83
4.5.2 Interviews....84
4.5.3 Laboratory and School Observation Schedules....85
4.5.4 Document Study....85
4.5.5 Photographs....86
4.6 Data Analysis....86
4.6.1 Procedures Employed in Reducing and Analysing Data....87
4.6.2 Looking for Patterns, Relationships and Themes within Categories....90
4.6.3 Use of Software in Data Analysis....92
4.6.4 Drawing Conclusions....94
4.6.5 The Indicators in the Theory of Implementation Framework....96
CHAPTER 5 SCHOOL STORIES....98
Introduction....98
5.1 DOMBOSHABA SENIOR SECONDARY SCHOOL....102
5.1.1 A Portrait of the School from my Observations....102
5.1.2 A Portrait of the School from the Perspective of the Teachers....106
5.1.3 Summary of Domboshaba SSS....114
5.2 TAGALA SENIOR SECONDARY SCHOOL....115
5.2.1 A Portrait of the School from my Observations....115
5.2.2 A Portrait of the School from the Perspective of the Teachers....119
5.2.3 Summary of Tagala SSS....128
5.3 MARU SENIOR SECONDARY SCHOOL....129
5.3.1 A Portrait of the School from my Observations....129
5.3.2 A Portrait of the School from the Perspectives of the Teachers....133
5.3.3 Summary of Maru SSS....140
5.4 LESEDI SENIOR SECONDARY SCHOOL....141
5.4.1 A Portrait of the School from my Observations....141
5.4.2 A Portrait of the School from the Perspective of the Teachers....146

5.4.3 Summary of Lesedi SSS 154
5.5 Patterns, Relationships and Themes 154
5.6 Potential to Implement 161
5.7 Determining Operational Levels 161
5.8 The Operational levels for the four Senior Secondary Schools 165
CHAPTER 6 DOMBOSHABA SSS 167
Introduction 171
6.1 Teachers' Profile 171
6.2 Teachers' Perceptions about the Curriculum Change 171
6.2.1 Curriculum Changes in Terms of the Syllabus 172
6.2.2 Changes in Terms of Assessment 172
6.2.3 Curriculum Changes in Terms Of Teaching Practice 173
6.3 Implementation in the Classroom 175
6.3.1 Lessons Given by Mr Kgabo 176
6.3.2 Lessons Given by Ms Malane 180
6.3.3 Lessons Given by Mr Pula 185
6.4 Hands on Activities – Practical Work 190
6.4.1 Experiments Observed 190
6.4.2 Common Features 191
6.4.3 Purposes of Practical Work 194
6.5 Summary of Findings: Teachers and their Teaching at Domboshaba SSS 196
6.5.1 Teachers and Curriculum Change 197
6.5.2 Teachers and their Practice 197
6.6 Discussion of Findings for Domboshaba SSS 199
6.6.1 The Practice 199
6.6.2 Transforming Indicators to Operational Levels 200
6.6.3 Discussing Domboshaba SSS Operational Levels 204
CHAPTER 7 TAGALA SSS 208
Introduction 208
7.1 Teachers' Profile 208
7.2 Teachers' Perceptions about the Curriculum Changes 209
7.2.1 Curriculum Changes in Terms of Syllabus 209
7.2.2 Curriculum Change in Terms of Assessment 210
7.2.3 Curriculum Changes in Terms of Teaching Practice 211
7.3 Implementation of the New Curriculum in Chemistry Classrooms 212
7.3.1 Lessons Given by Mr Mano 213
7.3.2 Lessons Given by Mr Mokone 218
7.4 Hands on Activities - Practical Work 225
7.4.1 Experiments Observed at Tagala SSS 226
7.4.2 Common Features of Practical Work – Perceptions and Practice 226
7.5 Summary of Findings about the Teachers and their Teaching at Tagala SSS 229
7.6 Discussions of Findings for Tagala SSS 232
CHAPTER 8 MARU SSS 237
Introduction 237
8.1 Teachers' Profile 237
8.2 Teachers' Perceptions about the Curriculum Change 238
8.2.1 Curriculum Changes in Terms of the Syllabus 238
8.2.2 Curriculum Changes in Terms of Assessment 239
8.2.3 Curriculum Changes in Terms of Practice 240

8.3 Implementation of the New Curriculum in Chemistry Classrooms.....242
8.3.1 Lessons Given by Mr Bose.....243
8.3.2 Classes Given by Mr Mpho.....248
8.3.3 Classes Given by Mr Sunny.....254
8.4 Hands on Activities – Practical Work.....258
8.4.1 Experiments Observed.....258
8.4.2 Common Features of Practical Work – Perceptions and Practice.....259
8.5 Summary of Findings about the Teachers and their Teaching at Maru SSS.....261
8.6 Discussions of Findings for Maru SSS.....263
CHAPTER 9 LESEDI SSS.....269
Introduction.....269
9.1 Teachers' Profile.....269
9.2 Teachers' Perceptions about the Curriculum Changes.....270
9.2.1 Changes in Terms of Chemistry Syllabus.....270
9.2.2 Changes in Terms of Assessment.....271
9.2.3 Changes in Terms of Teaching Practice.....272
9.2.4 Perceptions about the Readiness to Implement the New Curriculum.....273
9.3 Implementation of the New Curriculum in Classrooms.....274
9.3.1 Lessons Given by Ms Nakedi.....275
9.3.2 Lessons Given by Mr Kopano.....284
9.3.3 Lessons Given by Ms Bolaane.....290
9.4 Hands on Activities - Practical Work at Lesedi SSS.....295
9.4.1 Experiments Observed.....295
9.4.2 Purpose of Practical Work.....297
9.4.3 Practical Work - As Diagnostic Test.....297
9.5 Summary: The Teachers and their Teaching at Lesedi SSS.....298
9.6 Discussions of Findings for Lesedi SSS.....300
CHAPTER 10 DISCUSSION AND CONCLUSIONS.....306
Introduction.....306
10. 1 Overview of the Study.....306
10.2 Discussion of Findings.....307
10.2.1 Methodological Findings.....308
10.2.2 Applicability of the Rogan and Grayson's (2003) Framework.....308
10.2.3 The Operational Levels.....309
10.2.4 Determination of the Operational Levels and the ZFI.....310
10.2.5 Implications of the Study Research Sample on the Theory.....311
10.3 Findings in Terms Of Rogan and Grayson's Constructs.....312
10.3.1 Capacity to Support Innovation across Schools.....313
10.3.2 Profile of Implementation.....315
10.4 Capacity to Support Innovation and the Profile of Implementation.....319
10.5 Teacher Distribution in the Science Departments.....325
10.5.1 Influence of Distribution on Ecology of Science Departments.....327
10.5.2 Unifying Factors.....333
10.5.3 Influential Factors in Implementing a Chemistry Curriculum.....334
10.6 Conclusions.....336
10.6.1 Answers to the Research Questions.....336
10.6.3 Implications of Findings for Teachers, Schools and Educational Departments.....339
10.6.4 Reflection of Study.....341

REFERENCES.....**343**

LIST OF TABLES

Table 2.1: The path followed by the education system over the years 6
Table 2.2: Science curriculum changes from 1969 to present 7
Table 2.3: A summary of the Cambridge and BGCSE science curricula 14
Table 4.1: Recommended terms to deal with validity in qualitative inquiries 75
Table 4.2: Steps needed to ensure validation of data 76
Table 4.3: The research design 77
Table 4.4: The four secondary school related information 82
Table 5.1: An inventory of physical resources at the four secondary schools 101
Table 5.2: Summary of schools' ecology and management relations 155
Table 5.3 Summary of areas teachers felt uninvolved / problematic areas 157
Table 5.4: Capacity indicators of the four schools 163
Table 5.5: The levels of operation of teachers at the schools 165
Table 6.1: Secondary school, teacher & classroom related information 169
Table 6.2: A summary of the chemistry teachers' pedagogical profiles 171
Table 6.3: Experiments carried out by Domboshaba SSS teachers 191
Table 6.4: Domboshaba SSS teachers' perception about curriculum changes 196
Table 6.5: Domboshaba SSS teachers' teaching practice 198
Table 6.6: The Operational Indicators of Domboshaba SSS Teachers 199
Table 6.7: Matching practice indicators and those from Rogan and Grayson 200
Table 6.8: Matching other practice indicators and those from Rogan & Grayson 201
Table 6.9: The Teachers' Operational Level at Domboshaba SSS 202
Table 7.1: A summary of the chemistry teachers' pedagogical profiles 208
Table 7.2: Experiments carried out by Tagala SSS teachers 226
Table 7.3: Tagala SSS teachers' perception about curriculum changes 229
Table 7.4: Tagala SSS teachers' teaching practice 231
Table 7.5: The Operational Indicators of Tagala SSS teachers 232
Table 7.6: The levels of operation of teachers at Tagala SSS 232
Table 8.1: A summary of chemistry teachers' pedagogical profiles 237
Table 8.2: A drill mental puzzle, (W2D4 Bose, pg 2) 245
Table 8.3: Experiments carried out by Maru SSS teachers 259
Table 8.4: Maru SSS teachers' perception about curriculum changes 261
Table 8.5: Maru SSS teachers' Teaching Practice 262
Table 8.6: The Operational Indicators of Maru SSS Teachers 264
Table 8.7: Operational levels of teachers at Maru SSS 264
Table 9.1: A summary of Lesedi SSS chemistry teachers' pedagogical profiles 269
Table 9.2: Classroom presentations by Ms Nakedi's Learners 276
Table 9.3: A summary of problems encountered by learners during a practical 296
Table 9.4: Lesedi SSS teachers' perception about curriculum changes 298
Table 9.5: Lesedi SSS teachers' Teaching Practice 299
Table 9.6: The Operational Indicators of Lesedi SSS Teachers 300
Table 9.7: Operational levels of teachers at Lesedi SSS 301
Table 10.1: Teachers' Operational Levels at two schools showing mean, mode and median values 310
Table 10.2: A summary of intervention guide for the schools 324

LIST OF FIGURES

Figure 2.1: Structure of the Botswana Education System 19
Figure 3.1: The framework on which the research is based (Rogan & Grayson, 2003) 29
Figure 3.2: The gap between current and ideal practice 34
Figure 3.3: Developmental levels of implementation (adapted: Rogan & Grayson, 2003) 36
Figure 3.4: Indicators of Capacity to support innovation 37
Figure 3.5: Excerpt from a school and Appendix A showing physical resources 37
Figure 3.6: The teacher's community of practice linking the theory of curriculum implementation and situated perspectives. 42
Figure 4.1: The case boundaries 67
Figure 4.2: The replication figure illustrates the overview of this study 71
Figure 4.3: Overview of the geographic location of the participating schools 80
Figure 4.4: Data reduction process 87
Figure 4.5: Steps in typological analysis approach to reduce data analysis 88
Figure 4.6: A summary of steps taken in interpreting data 90
Figure 4.7: Hierarchy in generating and regrouping codes 93
Figure 4.8: Constructing categories 94
Figure 5.1: Domboshaba SSS science section 103
Figure 5.2: Physics and chemistry preparation room layout at Domboshaba SSS 104
Figure 5.3: A typical chemistry laboratory at Domboshaba SSS 106
Figure 5.4: An uninhabited workroom at Tagala SSS 118
Figure 5.5: One of the many unopened boxes at Tagala SSS science laboratories 119
Figure 5.6: Learners inside school standing by the main entrance 130
Figure 5.7: Tea time at Maru SSS science department 131
Figure 5.8: Layout of the renovated chemistry laboratories 132
Figure 5.9: The renovated chemistry laboratory at Maru SSS 132
Figure 5.10: A classroom's exterior wall showing lack of renovation 142
Figure 5.11: Teacher in the upper floor workroom looking at a scheme book 145
Figure 5.12: Schools' current capacity factors 165
Figure 6.1: Group practical work at Domboshaba SSS 192
Figure 6.2: A chemistry teacher and learners discussing experimental results 195
Figure 6.3: Domboshaba SSS' levels of operations 203
Figure 7.1: Single science learners performing an experiment in Tagala SSS 214
Figure 7.2: Teacher checking individual class exercises during a lesson in a lab. 219
Figure 7.3: Teacher demonstrating the movement of ammonia and hydrogen chloride gases to illustrate diffusion in gases 227
Figure 7.4: Tagala SSS' levels of operation 233
Figure 8.1: Students carrying out an experiment on displacement reactions at Maru SSS 260
Figure 8.2: Maru SSS' level of operation 265
Figure 9.1: Learners copying notes 287
Figure 9.2: Learners feeling groggy and having 287
Figure 9.3: Ms Bolaane marking a student's class exercise 290
Figure 9.4: Lesedi SSS learners performing a practical test 295
Figure 9.5: Investigative/qualitative Practical test 298
Figure 9.6: Lesedi SSS' levels of operation 301
Figure 10.1: Excerpt from Appendices B and D, showing a school's physical resources 309

Figure 10.2: Levels of capacity to support innovation 313
Figure 10.3: Levels of profile of implementation.....316
Figure 10.4: Excerpt from Appendix B showing a school's physical resources 316
Figure 10.5: Comparing capacity factors and practice 319
Figure 10.6: The type of teacher distribution found in the science department. 325
Figure 10.7: Factors influencing chemistry teaching in senior schools in Botswana 335

LIST OF APPENDICES

Appendix A: Rogan and Grayson - Profile of Curriculum Implementation.....359
Appendix B: Rogan and Grayson – Profile of Capacity to Support Innovation.....360
Appendix C: Profile of implementation contextualized for science teaching in Botswana senior secondary schools.....361
Appendix D: Profile of capacity to support innovation 362
Appendix E: Ministry of Education request letter.....363
Appendix F: School request letter 364
Appendix G: Science teacher request letter.....365
Appendix H: Checklist for Chemistry Laboratory 366
Appendix I: General-school Schedule 367
Appendix J: Teacher Interview Questions.....368
Appendix K: Notes from classroom observation and interview transcription.....369
Appendix L: Use of ATLAS.ti 370
Appendix M: BGCSE chemistry syllabus objectives 371

KEYWORDS

Curriculum; implementation; operational level; innovation, capacity, construct, sub-construct

CHAPTER 1 INTRODUCTION

Introduction

The past few years have seen numerous attempts at science education reforms in Africa directed at needs of individual countries. Pivotal issues in these countries tended to revolve around the nebulous concept of 'relevance' (Prophet & Vlaardingerbroek, 2003). This concept has been applied in a number of different educational dimensions, particularly relevance of subject matter and its relevance to the local situation and relevance to the slow learner or cultural relevance. An example of such a curriculum would be curriculum 2005 of South Africa (Rogan, 2004; Rogan & Grayson, 2003; Muwanga-Zake, 2000). In Botswana influential policy reports recommending comprehensive changes in science curriculum, teaching and learning were issued following the National Commission of Education in 1992 (Republic of Botswana, 1993). The curriculum reform involved the introduction of the Botswana General Certificate in Secondary Education (BGCSE), which replaced the Cambridge Overseas School Certificate Syllabuses. Introduction of the BGCSE represented an effort by the Botswana government to come up with a program suited to the needs and priorities of the country (Republic of Botswana, 1993).

There was a general feeling that the minimum level of scientific understanding that an ordinary Motswana should develop to live comfortably in a technologically oriented society has increased in recent years, resulting in national plans calling for a more scientifically literate national work force (Republic of Botswana, 1993). The focus was now on enhancing students' experiences outside the classroom as they engaged with content (Curriculum Blueprint: Republic of Botswana, 1998). Themes found in many reforms provided a direction for outlining some of the goals. These themes found in the recent wave of science education reform include constructivism, equity, science technology and society (STS), educational technology, cooperative learning, hands on activities, and the nature of science (Yoloye, 1986; 1998; Republic of Botswana, 1997).

1.1 The Problem

Through the restructuring of the curriculum objectives (to be discussed in chapter 2), it was hoped that the implementation of the BGCSE would bring a new approach to teaching and learning of science. Teachers were urged to offer students more learner-centred and activity-based instruction. Reforming pedagogies based on constructivists' theories stress the importance of learners' interests and conceptions. It appears that progress towards realisation of these and other goals has been slow and sporadic. There is an indication that to some extent the teachers are not doing much in implementing the prescribed teaching ideas. It was suspected that mind and hands-on activities are still limited, showing students were given less time to participate during lessons. Teachers continue to devote a lot of their time and effort to the transmission of content (Prophet & Rowell, 1993). This teaching style is consistent with transmission views of learning and teaching, which is in contrast to what the new curriculum advocates.

Curriculum documents usually contain professional themes, and the extent to which they are intended to influence and affect practice can be problematic to teachers (Pinto, 2005). Teachers have to translate these themes for themselves, which they do in various ways, in light of their own definitions and beliefs (Lumpe, Haney, & Czerniak, 1998). It is these definitions that can bring unexpected utilisation problems (Beeby, 1966; Bybee, 1991). The role of the teacher and particularly the teachers' beliefs about teaching must not be ignored if these recommendations will result in enduring change in classrooms. There is a notion that teachers' beliefs around a particular situation form attitudes and attitudes become action agendas that guide decisions and ultimately determine their professional practice (Gess-Newsome & Lederman, 1999; Lumpe et al., 1998). Hence knowing what the teachers are doing or what is in their minds is crucial.

1.2 Rationale of the Study

According to the BGCSE, teachers were now expected to organise learning environments that allowed learners to become knowledgeable by preparing them for the world of work. There was a redirection for the subject matter delivery to reflect technical skill development and application of science in society. The need to

transform and enrich interaction with the world led to innovative demands of technology rich, practical and inquiry based environments as opposed to traditional delivery approaches (Bybee, 1991; Koosimile, 2004). From a large range of possible curricular innovations, implementation of some three types was selected for this study. These includes

- Research into the implementation of innovative teaching sequence such as the introduction and use of activity-based learning for instance group-work, presentations, inquiry or investigative learning.
- The nature and use of practical work by chemistry teachers
- Research into the reflection on the nature of science, analogy use, application of science, day-to-day use of concepts of science; for scientific content.

An investigation into the implementation of the BGCSE seems a plausible research study, as there are still questions about how innovations are implemented in schools. The motivation of teachers for adopting new practices and the match between the understandings constructed by the teachers and those intended by the developers do not always meet (Hargreaves, 1992). This has been a motivational source for me to study this area since very few studies have been done in Botswana on curriculum implementation of the new curriculum and teacher change to give a clue of how well innovation is going.

1.3 Aims of the Study

This study specifically aims to find how teachers are putting curriculum demands into practice. These necessitated finding the nature of contexts that existed in the school. Chemistry classroom environments were investigated and capacity profiles outline drawn for the selected schools. This therefore allowed gaining insight as to whether schools and teachers are in a realistic state in terms of physical resources and interpretation of the syllabus to put demands into practice effectively. A cross-case study between schools was attempted to find out if there is a relation between the capacity to support innovation and the level of practice in chemistry education in selected schools. The usefulness of the zone of feasible implementation (ZFI) concept will be established and the possibility to identify specific areas of growth.

1.4 Purpose of the Study

The central concern of this project was to study general innovations in chemistry education, and investigate ways in which teachers transform these innovations when putting them into practice. That is, the study will try to understand and characterise transformations made by teachers when implementing the BGCSE. The research study will also investigate factors militating against successful implementation. It will then use these understandings to possibly suggest an intervention or teacher educational materials that address issues in the implementation of innovative curriculum ideas. This study will take advantage of a theory of curriculum implementation (Rogan & Grayson, 2003), to characterise transformation and find how best the spelled out innovations can be transformed into practice.

Though variance is expected, Rogan and Grayson (2003) admit that there is something that constitutes good practice, calling for a common understanding in the way teachers translate innovation to practice. Despite these observations about the importance of teacher factors in curriculum implementation (Rogan & Grayson, 2003; Berg, 1996; Verspoor, 1989), there is a general perception that little has been done to help teachers in bringing change in Botswana (Koosimile, 2004, 2005a; 2005b). To address such issues about the implementation, the research will look at how the BGCSE is being implemented in different schools, the teachers' attitudes towards the innovation and the teachers understanding of the new curriculum and its theoretical base. The theory of curriculum implementation by Rogan and Grayson (2003) will be useful in this regard.

1.5 Research Questions

The following research questions have been formulated to guide the study:

1. How is the BGCSE chemistry curriculum perceived by the chemistry teachers?
2. How is the teaching and learning of chemistry conceptualised by the teachers?
3. How do designs and organisations in schools promote or inhibit new curriculum implementation in Botswana secondary schools?

- What is the nature of resources in the science departments and how do they affect the implementation of curriculum in selected schools?

- How did the nature of the relationship between teachers and other staff members affect the implementation of the BGCSE and work during the period under review?

1.6 Significance of the Study

During previous curriculum implementations at both primary and junior secondary schools, the procedure in Botswana has always been to put new ideas into practice without discriminating measures (Koosimile, 2004; 2005b). Studies undertaken in Botswana at junior secondary school (Koosimile, 2004; 2005b) led to the expectation that although there has been little change of practice in various secondary schools across the country, there is no uniformity in the interpretation and implementation of the new science curriculum.

The uniqueness of this research study is therefore its intention to discover whether any operational differences of teachers exist in selected senior secondary schools, and to suggest why these disparities if any, exist, thereby allowing the researcher to develop profiles of the chemistry teachers' personal operational patterns. To do this the study will characterise transformations made by teachers when implementing the BGCSE, and their understanding of the requirements of the new curriculum. Their schools' capacities will be used as well, to see how well they are linking and translating into practice. Knowing more about the aspects of capacity will help seeing how chemistry teachers implement the chemistry syllabus. The teachers themselves come with their own professional histories and the departments and classrooms in which they work have their own dynamics. Insights gained will increase the understanding of how these teachers accept, adapt, or resist such changes. This is of interest to all those concerned with professional development of chemistry teachers. This could also be helpful for teachers of other science subjects. After identifying practices for various schools, recommendation of functional standards will be made to those schools where implementation has been unsatisfactory.

It is necessary to also give a background of the curriculum history of Botswana. This will be done in the chapter that follows.

CHAPTER 2 THE BOTSWANA CURRICULUM

2.1 Botswana's Curriculum History

In order to understand the setting for the study, it is necessary to take a look at the evolution of the Botswana educational system, especially its origins at primary school. This chapter introduces the long route it took to reach the current system. Table 2.1 below gives a skeleton map of the education system, showing how the years of basic education have changed.

Table 2.1: The path followed by the education system over the years

	1966 - 1977	1986 – 1989	1999 – present
Total Education	**Primary Education** Standard 1 – 7	**Primary Education** Standard 1 – 7	**Primary Education** Standard 1 – 7
	Junior Certificate Form 1 - 3	**Junior Certificate** Form 1 - 2	**Junior Certificate** Form 1 - 3
	Cambridge Form 4 – 5	**Cambridge:** Form 3 – 5	**BGCSE** Form 4 – 5
	Tertiary Education	**Tertiary Education**	**Tertiary Education**
System	7 – 3 – 2 7 year basic education - primary schooling only	7 – 2 – 3 9 year basic education implemented	7- 3 – 2 10 year basic education -primary & junior secondary

At attainment of independence in 1966, the government of Botswana inherited curricula at all levels (primary, junior and senior secondary) from the United Kingdom. The table above points at the priority of the government then to have children completing just their primary school (7 year basic education). The basic education was later extended to junior secondary level, which lasted 2 or 3 years.

Botswana's government believed that education had a role to play in the democratization process. One of the problems with the inherited curriculum was that the country's own people (e.g. teachers and other stakeholders) had not fully participated in the design and construction of the curriculum. The relevance of the curriculum was questioned as to whether it would reflect the aspirations of the Batswana (Republic of Botswana, 1977).

The need for revisions which took account of these factors were expressed in different forums and documented in several official reports such as National Development Plans, National Commission on Education reports of 1977 and 1993 and Revised

National Policy of Education of 1994. For instance, one of the stated aims was for the government to develop a primary and secondary curriculum that reflected the aspirations of the country as well as introducing appropriate teaching and assessment procedures. One of the government's first objectives was to develop appropriate assessment procedures to match the revised curriculum and begin the development of a local form five examination to replace the Cambridge overseas school certificate, COSC. An outline of the years of revision is given on table 2.2 below.

Table 2.2: Science curriculum changes from 1969 to present

Year	Driving force and/or changes
1969	Additions: • Discovery learning emphasis on Nature study curriculum • New Primary Science syllabus
1977	• Commission of Inquiry report • 1977 task force • Recommend - 9 yr basic education • 7 yr basic education in place & Primary Science Syllabus reviewed
1982	• New Science syllabus Introduced (Primary)– to express local culture and prior knowledge • Science became examinable at primary (Primary School Leaving Examinations PSLE)
1986	• 9-year basic education implemented • Basic education made available to all children (free secondary education)
1989	• New Primary science panel to develop syllabus suitable for all pupils (9 year basic education)
1992	• New primary science syllabus implemented: emphasis on process skills
1993-present	• 1993: National Commission of inquiry on Education report • Localisation of BGCSE 1998

The dawn of independence witnessed concerted efforts on the part of the government to revamp education. The table above shows the numerous curriculum innovations that attempted to bring improvements.

The major changes immediately after independence were focused mainly on development of primary education. Of all the levels and types of education the commission was tasked to consider, the commission felt bound to accord the highest priority to improvement and reform at the primary level. Primary education was identified as the most important stage of education as it was aimed at providing a common foundation of basic learning for everyone (Republic of Botswana, 1977).

2.1.1 Primary School Education

Records show that the revision of the primary and the secondary science education was done in stages from 1965 to 1992 and of the junior secondary science from 1967 to 1996 (Yandila, 1999). One of the aims of developing new curricula was to generate

adequate human resources for national development. Science was seen to play a vital role in facilitating this development. The 1967 nature study curriculum was replaced by a new science syllabus in 1969 following the 1965 commission of inquiry on education. The 1969 primary science syllabus placed a lot of emphasis on process skills and discovery learning derived from the Nuffield primary science syllabus from the UK (Prophet and Thapa, 1999). It was not surprising in these years to find that the science curriculum reflected the UK curriculum because expertise for the development of science curriculum came mainly from persons familiar with the UK syllabus.

Despite the commitment to discovery learning and process skills development, much of the content was not able to be processed by either pupils or teachers. Due to the fairly rapid expansion of education structures, teacher education placed more emphasis on teaching methods than on what to teach. Failure to address content led to the presence of unqualified teachers teaching science (Prophet and Thapa, 1999).

In the early 1980's, at the time of considering the implementation of another 1977 recommendation (the nine year basic education for all), the 1969 primary curriculum was reviewed. A diluted version of the revised science syllabus was later introduced, which would meet the weak educational background of teachers. However, for the first time the syllabus stressed the importance of the local culture and local knowledge that learners bring to school (Prophet and Thapa, 1999). The emphasis on using process skills such as observing, sorting, classifying, experimenting etc. as a vehicle to teaching science were stated as objectives (Prophet and Thapa, 1999; Taiwo, 1999).

A number of other supportive developments took place at the same time to ensure the success of primary teaching science such as

- Science becoming one of the subjects to be examined in the Primary School Leaving Examinations (PSLE)
- Science content and pedagogy becoming part of the new curriculum of primary teacher training colleges
- Teachers' guides being developed which provided teachers with suggestions for activities

In the mid eighties, the move to the nine year basic education for all was implemented in schools. Pupils were now to follow a seven year primary schooling followed by two years of junior secondary schooling. Basic education was made available to all Batswana children, irrespective of ability. Though there was still a national exit examination after the basic stage, promotion of students between the primary and junior secondary phases was not screened as all were allowed to pass through. However, due to the incompatibility of the primary and junior school curricula, a new primary science panel was established (in 1989), tasked with developing a primary science syllabus suitable for all pupils. This was necessary to cater for the low ability students. The new science curriculum was then implemented in 1992, placing emphasis on process skills. This primary science program was designed in the form of modules. For instance, lower primary (standard 1–4) science modules were based on development of individual learner's process skills. Upper primary (standard 5-7) modules were organised around science topics which were of immediate concern in pupil to everyday life. Science process skills were integrated with content.

2.1.2 Post Primary Education

The first stage of education was to provide a common foundation of basic learning for everyone. The next task comprised not only exposing all learners to basic education, but also to prepare where they go at the end of education up to the age of about 18. The forms of education and training that took place soon after primary education such as secondary school, brigades training, apprenticeship, vocational schooling, training in nursing and teaching were made available to receive them (Republic of Botswana, 1977).

In 1986, the government of Botswana introduced a 2 year junior certificate (JC), phasing out the previous 3 year BOLESWA integrated science. According to Nganunu (1988), the 3 year JC was a nature study based science curriculum that was aimed at introducing learners to beginners' science. Introduction of the 2 year JC saw the break away from the formerly BOLESWA curriculum, but saw a new beginning in introducing integrated science that was aimed at exposing learners to both hands and activity-based learning. The integrated science stint was short following recommendation by the education inquiry of 1993 which brought another version of a 3 year JC. The changes were mainly to restructure the syllabus to fit the two or three

year junior school duration. Following the introduction of the 10 year basic education, there was an issue of organising the curriculum to suit the wider ability range of students from primary that now proceeded to junior secondary education (Republic of Botswana, 1993). The 'Education for Kagisano' commission emphasized universal access to nine years of schooling by about 1990 and therefore concentrated on basic education (Republic of Botswana, 1977).

Senior secondary schooling did not feature much. Revision of the senior science curriculum was not undertaken until 1995, following the 1992 inquiry on education. With a solid basic education, the 1992 commission recommended

- A fully fledged autonomous national examination council to be established
- Training of markers and examiners
- Rewriting and adapting the syllabus - with more emphasis on local relevance and context
- Examination papers be set and a grading system to be developed with Cambridge moderation
- Provision of physical facilities

Due to these recommendations, there was now a great desire in education circles to move away from the Cambridge curriculum and to localize the whole education system.

2.2 The Cambridge Overseas School Certificate (COSC) Curriculum

From independence till the mid-eighties, junior secondary schools offered integrated science (general science). Senior secondary education largely remained dependent on the inherited Cambridge curriculum called COSC. The duration of senior secondary education changed twice from two to three year duration. For some time the curriculum development unit, in the Ministry of Education saw nothing wrong with taking and using the UK curriculum as it was. Science was viewed as a body of knowledge, independent of context (Ogunniyi, 1986; 1995b; Republic of Botswana, 1977), hence the foreign curriculum was considered relevant and useful. Where the context was largely national as for example in social studies and Setswana subjects, special curricula were introduced locally developed (Republic of Botswana, 1977).

The old science curriculum offered different syllabus options targeting various ability and interest groups. The options were as follows;

- Pure science subjects with separate courses in biology, chemistry and physics (referred to as triple science or separate sciences)
- A varied combination of any two science subjects: physics/chemistry; physics/biology; chemistry/biology (referred to as double science).
- Combined science, which was a single subject combination of biology, chemistry and physics (referred to as single science)

According to Prophet and Vlaardingerbroek (2003) and Koosimile (2004), science education in Botswana had at that time no relevance to real life. This characteristic was reinforced by the transmission approach to teaching which by nature is limited to rote learning methodologies (Prophet, 1995). A structure of the two curricula is given in table 2.3. It is worth noting that the Cambridge curriculum had a lot of influence in the structure of the new BGCSE curriculum. The BGCSE has remained remarkably similar in key areas such as the target groups of the streams, the content and to some extent the times allocated to science streams.

Major differences can be seen when looking at the philosophies of the two curricula. The new curriculum aimed to guarantee that all learners were exposed to all the 3 science disciples. In the old curriculum it was possible that learners could pick a combination of physics and chemistry and not take biology. This is not possible in the current set up (Curriculum Blue Print: Republic of Botswana, 1998). This is so because all the 3 streams are made up of components of biology, chemistry and physics, but to different degrees of depth.

DISCUSSION OF THE COSC (OLD) CURRICULUM

The pure sciences were intended for students interested in pursuing a science-based career. This was largely favoured in view of the fact that Botswana's interest was in having an internationally recognised level of education (examinations). Due to the limited range of science-based programs in the country, students could be sent abroad for further studies. The watered-down double combination (called physical science) was intended for the less capable students who might still possibly pursue a science-based career. The watered-down combinations were locally recognised. For example, the rapid expansion in educational services resulting in watered-down teacher

education programs aimed at primary and junior secondary school teaching. Students taking physical science were considered for this program. Admission criteria were tinkered with to accommodate many student-teachers to make some of these learners trainable. According to Taiwo (1999), this resulted in the fulfilment of the saying that 'those who can't, teach'.

The physical science stream required students to take one pure science subject and a second set of two integrated subjects. It gave this choice a status of two subjects. For instance, a popular combination in most schools was an integrated physics and chemistry, complemented by taking pure biology or agriculture. On its own, a physics/chemistry combination was credited as a single subject. The three sciences combined into a single subject were even less cognitively demanding, intended for those whose career interests were outside the science fields. The combination was only intended to promote science literacy, but many of these taking this subject were absorbed into teaching and nursing professions due to shortages. The bulky nature of the syllabus meant learners taking the option were taught more or less the same topics offered to those taking pure and physical science options. This was in line with upholding the principle of science for all, that is having consideration for those who are going to continue to tertiary and those who will not (Lewin, 1985).

2.3 The New BGCSE Curriculum

The education objectives emphasise that the curriculum is more than a series of subject contents. To promote science literacy, all pupils were to study at least one science subject (stream) at senior secondary level. It could be said that these science options were intended to provide individuals, whose careers were outside science, with an understanding about scientific knowledge and skills that every citizen needs to exist meaningfully in a society (Republic of Botswana, 1993). Such options were targeted for what Yager (1986) sees as the majority of the learners rather than just the minority who took the more challenging options. Layton (1986) agrees with such a division of the curriculum on the grounds that it ensures that all pupils have sufficient grounding in the knowledge and skills which forms part of their general knowledge. The way the curriculum was structured seems to support this view, but whether its delivery meets criteria for teaching for science literacy is another thing.

Why Change?

There were many academic, political and economic reasons for wanting to localise the whole curriculum. The Botswana ministry of education previously had little influence on the content and context of the syllabus and the examinations. After years of independence, parents and students alike felt that the government should be in a position to develop and improve the educational situation at secondary level. It was felt that the country should have full control of education by developing the syllabus, setting examinations and administering them locally at all levels (Rowell, 1990). Economically this was viewed as a positive step since it would reduce the amount of money paid to the University of Cambridge Local Examination Syndicate (UCLES) in examination fees and for acquisition of other curriculum documents such as syllabuses.

There also were some sentiments that the old Cambridge programme was defective in many ways. The Cambridge programme was not well integrated with the preceding junior certificate or with the subsequent programme, the University of Botswana (UB) programme (Motswiri, 2004; Cantrell, Kouwenhoven, Mokoena & Thijs, 1993). Some students did not cope well with the teaching styles at university, an indication of the incompatibility of the Cambridge curriculum with the UB programmes. The Cambridge science curriculum in particular was believed to lack articulation and coordination with other local institution's programmes (Cantrell et al., 1993).

The old Cambridge curriculum's lack of relevance to real life was believed to be inclined more to stressing of facts, theories and to encouraging rote learning (Prophet & Rowell, 1993; Rowell & Prophet, 1990). The applied examples found were also said to be of contexts having little relevance to the local Batswana. All of these factors were associated with the ills of poor performance in examinations and even poor teaching and learning styles (Prophet & Thapa, 1999). This led to the introduction of a 6-month UB science-bridging programme called the Pre-Entry Science Course (PESC) in 1977 to help make Cambridge curriculum work (Cantrell et al., 1993). Despite this, dissatisfaction with the COSC curriculum continued.

2.4 The Localisation Requirements (Organisation)

Following the 1992 Commission of Inquiry on education, the Ministry of Education in partnership with the UCLES embarked on a phased program in 1995 to 2003 to localize the curriculum, the examination processing system and marking of examination papers (Yandila, 1999). The development of the curriculum and instructional materials was to reflect the world of work and promote integration across subjects. Some of the goals of the senior secondary school syllabuses and examinations were that they should cater for a wider ability group (Tabulawa, 1997). There was also a desire to improve the quality of secondary education by shifting from a teacher-centred pedagogy to a participatory, learner-centred one. Botswana has a democracy whose development is guided by a national philosophy of social harmony embracing concepts of social justice, interdependence, and mutual assistance (Republic of Botswana, 1977). A learner-centred pedagogy was seen as one of the ways of infusing and extending democratic practice to the micro-level of the classroom (Tabulawa, 1997).

The table below gives a summary of nature of science subject selection that was possible during the old and new curriculum.

Table 2.3: A summary of the Cambridge and BGCSE science curricula

	Old- Cambridge			**New - BGCSE**		
Stream	Pure	Physical science	Combined science	Triple	Double	Single
Subjects	Biology Chemistry Physics	2 combined	3 combined	Biology Chemistry Physics	3 combined	3 combined
Credit	3	1	1	3	2	1
Periods per week	15	12	9	18	12	9

In the current curriculum, all learners have to take chemistry subject.

2.4.1 Development of the New Chemistry Curriculum

Since this thesis is focusing on chemistry education, development of the chemistry curriculum will be looked at. The curriculum development had a gradual beginning starting with the organisation of a Task Force committee in 1994. The chemistry committee was made up of professional chemists and chemistry educators from within the country. One of their tasks was the restructuring of the syllabus, especially

with respect to new goals, objectives and introduction of new topics that added local flavour. Botswana currently engages in large scale mining of diamonds, coal and soda ash. Coal and other minerals are mainly for local consumption. The large scale mining of these minerals resulted in the expansion of the topic Carbon and Carbonates. New objectives were included involving:

- Description of the process involved in the extraction and refining of diamonds in Botswana
- Comparison of the structure of graphite, diamond and silica
- Description of the manufacture of sodium carbonate by the Solvay process etc

Armed with some of the themes of modern science education such as constructivism, science technology and society, cooperative learning, hands-on activities and the nature of science, the chemistry curriculum was to present scientific knowledge in more authentic contexts, promote meaningful learning through for example cooperation learning (Roth, 1995; Newton, Driver & Osborne, 1999; Atkins & Black, 1996).

2.4.2 Organisation of the Chemistry Curriculum

Within their framework, the task force organised the syllabus such that learners of various abilities had differentiated access to some chemistry knowledge (Layton, 1986). Like the Cambridge curriculum, to cater for varied learning-ability groups, the content of the new chemistry curriculum was organised into three broad areas, the single, double and the triple science syllabi as mentioned above (Table 2.3):

- The triple science curriculum is composed of pure chemistry, pure physics and pure biology content.
- The double science has components comprising two thirds of each of the three pure sciences syllabus combined (biology, chemistry and physics). This gives double science a status of two credits.
- The single science syllabus has an even smaller contribution of the three, each contributing just a third of the triple science content. This leads to reduction of cognitive demand in the single science, giving it the status of one credit.

Each of the three syllabi was also further divided into a core component, which is the subject content for all students within a stream, and another challenging extension of the core aimed at the higher achievers. It was believed that this would cater for varied abilities within a stream (Layton, 1986; Republic of Botswana, 1993). At the policy level, the single and double science curricula were supposed to contain relatively few topics and concepts with lower difficulty level and to ease the problem of time. But reverting to the old system dominated by content and not guided by science literacy as first envisaged has meant the single science curricula became bulky.

Other changes introduced to the new curriculum were the teaching time allocations. For instance, the triple chemistry stream was allocated six periods a week; the double chemistry component was allocated four periods and the single chemistry stream, just three periods in a week. All of these factors have implications for teaching and learning in the various streams as prescribed by the policies.

2.4.3 Science for All

In the old curriculum, science was compulsory for all students. Broad access to scientific information was seen as key for people to understand, participate and respond to the challenges that development poses to civilization. During the new curriculum development, the government continued to acknowledge that a huge majority of a population being scientifically illiterate in a modern democratic society would be a prescription for disaster. But since not all students have the interest in pursuing science careers, triple sciences were considered irrelevant to those whose interest lay elsewhere. This was due to the recognition that a significant number of issues affecting the society today have a major scientific or technological component. For instance, issues outlined in the curriculum blue print of 1998, such as debates about HIV/AIDS, environmental issues, bio-technology issues etc. Having a work force that is not comfortable with scientific issues in this global village would be counter productive (Driver, Leach, Millar & Scott, 1997; Lederman, 1992; Yager & Weld, 1999).

To achieve a significant increase in science literacy, all students were again obliged to take a science subject. Revamping the science program was intending to bring

scientific literacy to those who struggled even with combined sciences. The low ability group was offered a prepared moderate single science course. Its goals were to teach, the epistemology of the scientific method by example. The history of science was to be put across in such a way that students would learn science in a more interactive, liberal way (Driver et al., 1997).

The present curriculum fell into trap of following closely the old curriculum's outline. It became too bulky through attempting to include most of the learning specific objectives from the previous curriculum. According to Gilbert (2006), this can provide challenges for the development of context-based or literacy chemistry curricula. Gilbert (2006) advocated selecting representative content rather than providing an overview of the curriculum. This allows for learners to develop coherent meaning about what they are learning in chemistry (Pilot & Bulte, 2006b). It was hoped that the curriculum would be taught by a single teacher in an integrated manner to allow for development of coherent mental schema. Teachers have chosen to ignore the policy, and separated the subject into three, taught by a biology, chemistry and physics specific teacher. Reduction of the duration of the BGCSE meant chasing the content became a priority to complete the syllabus. The literacy component as envisaged by the developers has become challenged. Teachers failed to find mechanisms that give rationale for integrating the disciplines through a representative content and preferred to give disjointed curriculum (Motswiri, 2004)

2.5 The Chemistry Curriculum

In the new chemistry curriculum a comprehensive set of new goals and objectives was thoroughly articulated. These were associated with process objectives. It was clear that the teaching and learning modes that supported the new curriculum had to change. Teachers would now have varied tasks and have to rethink science through multiple images such as content, context process skills and future educational benefits for learners (Pilot & Bulte, 2006b; Prophet & Vlaardingerbroek, 2003). This contradicts with the image of curriculum as content that used to dominate the traditional Botswana curriculum (Prophet, 1995). Some of the specific aims of the chemistry curriculum were according to the Revised National Policy on Education, (Republic of Botswana, 1993), to:

- Develop manipulative skills which would assist students in solving technical and technological problems as they relate to day-to-day life situations.
- Develop positive attitudes such as open mindedness, inventiveness, concern for accuracy and precision, objectivity, integrity and initiative towards scientific skills.
- Develop abilities and skills such as experimenting and investigating that are relevant to a study using safe practice and application of science.
- Develop problem solving, critical thinking, communication, inquiry, and team work/interpersonal skills to help learners to be productive and adaptive in coping in a changing environment.
- Create an awareness of chemistry and recognize the limitations of the scientific method.
- Promote awareness that the application of science may be both beneficial and detrimental to the individual, community and the environment

Specific objectives were outlined for each topic, some of these requiring the use of practical work. For instance words such as 'carrying out', 'demonstrating', 'investigating' or 'conducting an experiment' were attached to content.

Preparations for Change

Completing the development of the curriculum fulfilled the part of the effort to localize the curriculum. To accommodate a larger progression from JC, extra physical facilities and teachers were required in most schools. This included physical facilities such as classrooms, administration blocks, science laboratories, storerooms and staffrooms. In some schools, these additional facilities necessitated expanding the existing school facilities in stages. This had to be reconciled with other requirements such as provision of a 10 year basic education for all. That is the implementation of a three year JC required a revised curriculum.

2.6 The Current Education System

The 2 year BGCSE curriculum is offered following a 10 year basic education for all (7-3 pattern). During the last few years, junior secondary education was now open to about 98% of the learners. This means that all learners leaving the 736 primary schools (about 40 000) in Botswana were accommodated in the 206 junior secondary

schools for their junior secondary studies (Republic of Botswana: Education Statistics, 2003; 2004).

The figure below summarises the current structure of education in Botswana. This also shows the educational opportunities and how learners progress starting from the point they join primary schooling to various phases such as primary schooling, junior secondary, senior secondary and college. It is worth noting that schooling at these levels is offered in different and separated institutions.

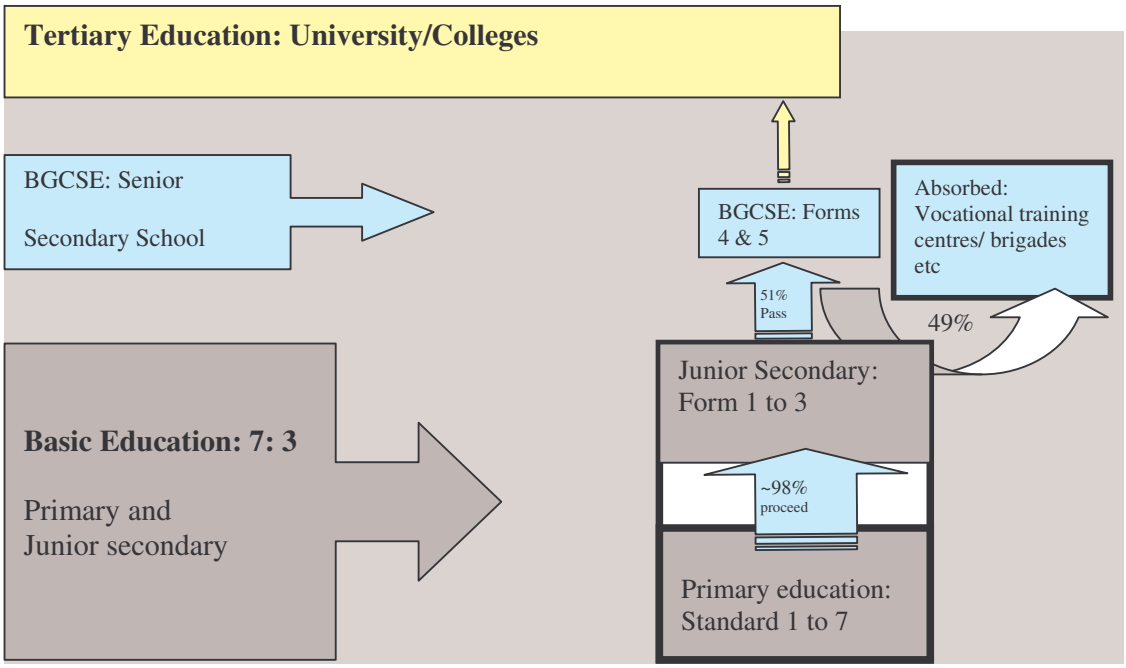


Figure 2.1: Structure of the Botswana Education System

Botswana has been able to counter low primary school completion rates. Between 1966 and 2000, primary school enrolment rose significantly from 66,100 to 327,600, representing an average compound growth of 4.8% per annum. Key to Botswana education is the commitment to a universal 10 year cycle of schooling. It is compulsory for all learners to take primary and junior secondary schooling.

Progression to the BGCSE is controlled by success in the competitive junior certificate terminal examination. The present transition rate from junior school to senior school stands at about 51%, though the pass rate (A, B and C grades) are higher. Progression is stifled both by performance and availability of spaces for study

at senior secondary schools. An absorption level of 51% is not surprising as there were only 27 government senior secondary schools at the time of the study.

2.6.1 Drop-Outs

While there was a massive expansion at the basic education level, the government emphasized selective assess to senior secondary school giving opportunities only to the best JC learners to progress. The current policy is to restrict the scale of senior secondary education in accordance with projected requirements for higher level human resources. This was to avoid producing more BGCSE holders than can be absorbed in education, training, and the labour market. Though only a smaller percentage (~25%) was initially envisaged, public pressure persuaded the government to allow schools to admit more learners (51%), than planned for. It was still not feasible financially to cater for all the learners, the government has therefore seen it fit to expand on the part-time study, and learning opportunities for the rest (49%) of the JC leavers through study groups (Koosimile, 2004).

Out of school programmes to cater for learners who do not pass JC or are not absorbed to senior secondary phase are supervised by the distance education department within the MoE. This was mainly privately organized groups of private schools for learners to improve their examination grades. Learners dropping out of JC without intentions to improve their grades are usually absorbed into vocational training centres, apprenticeship colleges and brigades (Republic of Botswana, 1993).

Learners completing the BGCSE certificate can be absorbed in tertiary institutions such as Universities, Colleges of Education and Nursing, Polytechnic, Botswana College of Agriculture, Botswana Accountancy College, Botswana Institute of Administration and Commerce, Roads Training Centre etc (Republic of Botswana, 1993). The JC school dropouts are not the main focus of the study and therefore their destiny is beyond the scope of this thesis.

2.6.2 Progression to Senior Secondary Education

The school system produces a hierarchy based on success or failure of students from junior certificate. All learners progressing to BGCSE have to take one of the science

streams already described. This could be single science, double science or triple science. Allocation to science streams is based on learners' science and mathematics performance grades at JC level. In the past, learners who obtained excellent grades, usually 'A' and 'B' (ranging from 70% and above) were encouraged to take triple sciences. Those achieving less than A or B grades are selected to take double science stream. But recently, a move towards having more triple science classes than the double and single streams has seen learners with lower grades selected for triple science stream.

The prevailing situation at senior secondary level is that there is a wide choice of science subjects for those who wish to follow a science based career. For example the more science inclined students can take triple sciences. Taking a triple science stream means a student already has three science subjects biology, physics and chemistry. The learner has fewer choices of subject to make considering that there are automatic selections from compulsory subjects like English, Setswana and mathematics. The double science option is an equivalent of two credits. For instance a learner who obtains a 'B' grade in this option will be awarded two B credits. Single science award is given a status of just one subject due to its less demanding content. The single science stream is usually offered to those who obtained relatively poor mathematics and science JC results. However taking into consideration that only about half of those passing JC progress to senior secondary, it could be argued that learners taking the single science are nonetheless good to above average learners. Hence, they are generally regarded as the arts-oriented students.

The general aims of the three science streams are the same. The broader science curriculum for senior secondary school takes cognizance of the nature of knowledge, the contribution different subjects are able to make and the infusion of sensitive emerging issues such as HIV/AIDS. The learners in all three streams are supposed to be provided with relevant learning experiences, promotion of active learning through a variety of methods. Basically, there is now an emphasis on a shift from a teacher-centred pedagogy to a participatory, learner-centred approach for all streams. But the lack of specific objectives of such issues in the chemistry curriculum, has led teachers to ignore these issues. They are not really infused into the chemistry curriculum, but

teachers do touch such issues in passing, some are touched in depth during guidance and counselling sessions and assembly presentations.

2.7 Innovative Teaching

Looking at the goals of the new curriculum, it is evident that the innovations included the extent to which students would get involved in critical negotiations or constructive discussion during their learning which is commonly known as activity-based learning (Newton, Driver & Osborne, 1999). One of the purposes of the new curriculum was the need to improve the effectiveness of science teaching and learning, requiring teachers to plan new and unusual activities for teaching. Teachers were also required to create classroom environments in which lesson learned were relevant to real life situations and to make learning more meaningful and interesting to learners (Curriculum Blue Print: Republic of Botswana, 1998; Republic of Botswana: chemistry syllabus, 1998). Teachers now had to integrate experiments, class discussions and group work, ensuring learners were engaged in hands-on activities as well as constructive, critical and reflective talks. One of the most important media for achieving this was regarded to be practical work (Curriculum Blue Print: Republic of Botswana, 1998).

2.7.1 The Recommended Teaching Methods

The BGCSE chemistry syllabus hence encourages a learner-centred approach. It emphasises 'science process skills, problem solving skills, and the acquisition of hands-on experience, which are intended to increase the participation, and performance of all students' (Curriculum Blue Print: Republic of Botswana, 1998). Teachers are to approach the teaching-learning process using a variety of methods such as "inquiry, demonstrations, practical work, project work, discussions. To facilitate this kind of teaching requires teachers to pre-plan these activities. These way teachers would be able to expose learners to practical application of chemistry in everyday life situations.

2.7.2 Challenges

The major challenge to curriculum reform has always been its implementation (Hord, 1987; Kelly, 1999; Fullan, 1998; Rogan & Grayson, 2003). It is often assumed that

exposure to new materials would encourage teachers to change their teaching practices and eventually their beliefs about their students (Fullan, 1998). Research shows that even though there is a great potential for change through new materials, change itself is influenced by many other factors such as teachers' beliefs (Fullan, 1998; Kelly, 1999; Pinto, 2004), the nature of the innovation itself and capacity of the schools (Rogan & Aldous, 2005).

2.8 The Teachers

The introduction of the curriculum brought new demands, which have been discussed. During the implementation period, there was a big change in the type of teachers in senior secondary schools. There were now an ever increasing proportion of local young graduating teachers combined with a high turn-over of the teachers from overseas (Thijs, 1999). Most of these had been volunteer teachers who came with their own characteristics and youthful enthusiasm but with little or no teacher training, little, if any teaching experience and only a limited awareness of the school situations in Botswana (van Maarseven, 1995). For many local young teachers taking over, the approach to the BGCSE was something quite unfamiliar. There were not many teachers of long experience to help the young inexperienced teachers. There was a lack of continuity of teachers in the secondary schools because of the rapid turnover caused by short-term volunteers and other local teachers either transferring to another school or leaving the profession (Thijs, 1999; Republic of Botswana: Education Statistics, 2003). Another aspect of the BGCSE which has to be considered was the support offered to teachers.

Teacher Support

Teachers were urged to offer students more individualised instruction without taking into account the conditions under which they worked. Introducing innovative curricula and methods brings a variety of problems (Fullan, 2001; Hargreaves, 1992; Hargreaves & Dowe, 1990). This explains why there was support given to teachers at the beginning of the implementation of the new curriculum in Botswana (Koosimile, 2005b). In Botswana, teacher support for professional development was provided through education centres. Their main responsibility was to provide teachers with the necessary professional support for effective implementation of the new school

curriculum. Staff development committees were established in the schools to act as liaison organs with the centres for the professional development of teachers. In some instances in-service Education Officers conducted school-based workshops whereby they work with teachers in their regular environment.

It is well known that only if teachers feel some sense of ownership will they effectively carry out an innovation in the classroom (Pinto, 2005; Kelly, 1999; Hargreaves & Dowe, 1990). This makes it imperative that the roles of the teacher and particularly the teachers' beliefs about teaching must not be ignored if there is to be enduring change in the classroom (Tsai, 2001; Fullan, 1998, Tabulawa, 1997). In the past, major reform in science education failed to treat teacher development as an active process and assumed that a teacher-proof curriculum could be successfully implemented in a context free-environment (Hord, 1987; Havelock, 1973; 1977). Realisation of the important position of a teacher has led to a changed approach (Rogan & Grayson, 2003).

The Department of Mathematics and Science Education In-service at the University of Botswana has significantly contributed to the quality of improvement of teachers, departmental heads and school principals. They organized professional development programmes for teachers soon after the implementation had begun (Yandila, 2001; Tabulawa, 1997). The aims were to:

- Run workshops for teachers on various topics.
- To organize school activities and cluster meetings in different regions for teachers and heads of department.
- To provide an effective and coherent in-service education programme to support the implementation of government policies and recommendations.
- To identify the needs of schools and to be responsive and sensitive to their requirements and difficulties through provision of support services.
- To develop training programs which would foster the professional development of all teachers in order to make them more effective classroom practitioners.

Generally the initial workshops were organized for teachers to go through the new curricula in terms of how they were designed, the philosophy, aims, structure, and

content as well as adopted teaching and assessment approaches. Workshops were also organized on preparation, running and assessing practical work, designing and trying exemplary lesson and different teaching methods and strategies (Motswiri, 2004).

It remains to be seen whether the assistance they received was enough for them to stand on their own. Though it could be said that teachers found the workshops helpful, there were some challenges. For instance, due to logistical reasons, not all teachers could attend the workshops as the workshops were centralised. Large distances between schools have also been linked to the difficulties in having more teachers attending professional development activities. Those who attend are expected to run similar workshops for their colleagues but most did not. For those who did, it could also be argued that teachers who attend workshops and later run workshops in their schools may not transfer the planned knowledge and skills as efficiently as a trained facilitator would (Tabulawa, 1997). This should be expected as Kelly (1999) had made an observation that more functional professional support are those that are context specific, tailor made for schools on request.

Teachers develop beliefs about teaching from years spent in classrooms as both learners and teachers (Lumpe et al., 1998; Brickhouse, 1989). This critical relationship between the beliefs of teachers regarding implementation of science education, reform efforts and instructional decisions are very important to know. This is so because teachers' beliefs are critical ingredients in the factors that determine what happens in classrooms (Lumpe et al., 1998; Brickhouse, 1989; Tobin, 1996). It could be said that international literature points to the relationship between teachers' perspectives and pedagogical change. Hurst (1981) also pointed out that teachers are most likely to adopt or implement an innovation that is consistent with their internal cognitive styles and strategies. Thus there is a need to know what teachers think and know about their practices and the curriculum change.

Another aspect of Botswana educational system worth noting was the issue of disciplining students in senior secondary school. It is important to know because in chapter 5, discipline especially corporal punishment formed an important part of teachers' routine in their work.

2.9 General Student Discipline

Corporal punishment is a universal form of punishment employed by parents and is enshrined in the Tswana customs and tradition (Tafa, 2002; Sebonego, 1994). Studies conducted in Botswana shows that beating children is culturally and traditionally accepted as part of child rearing practices (Tafa, 2002; Shumba & Moorad, 2000; Sebonego, 1994). In Botswana, the penal code allows for the infliction of corporal punishment on child offenders under 18 years of age as long as the punishment does not exceed six strokes, whilst the customary limits the strokes to four (Sebonego, 1994). It is clear from these codes that corporal punishment by adults is legal but also restricted (Tafa, 2002). Though it is legalized in Botswana, there is no report of its enforcement. Though restricted and on the other hand, the United Nations Convention on the Rights of the Child views such treatment of children as inhuman and as physical abuse of children (Van Bueren, 1995). This has not stopped schools making it as part of their major disciplinary modes.

Taking a code of conduct from one schools in the country to represent what was going on in schools, it was found that the section of discipline clearly points out the teachers' position over learners stating that '*all teaching staff have authority over all students at all times*' (Maru SSS Prospectus, 2003/4). Students discipline is generally left to the discretion of the teacher, but with their roles generally seen also as parenting, the cultural and traditional practices of discipline are observed. According to Maru SSS school prospectus, teachers:

> …are expected to work as a team in moulding students' behaviour. If he or she (teacher) sees a student misbehaving on or off school premises, he/she should take immediate action (Maru SSS Prospectus, 2003/4).

Teachers are given the mandate to discipline learners in whatever way they deem appropriate but guided by 'the code of Regulations of the Ministry of Education'. According to the school guidelines,

> Students who shall violate regulations… will be warned first. If the violations are broken again… will be given five strokes of the cane…depending on the nature of offence (Maru SSS Prospectus, 2003/4).

Though such measures are reserved for punishing indiscipline, they have found use in punishing students for not doing well in class and other failures were other forms of

interventions could have worked. This has remained the preferred means to help curb bad behavior and improve the smooth running of most schools.

2.10 Summary

This chapter looked at the journey taken by the education system of Botswana. Most of the changes concerning science occurred at primary school level. The government of Botswana wanted to have a good foundation so as to later build on secondary school level. Building a strong foundation at primary school level has seen the government opening doors for all learners to study which complicated the quality of education offered. Education had to be made free at primary school level. Extending basic education to 9 years (primary to junior secondary) of free education extended opportunities learners had to pursue their study. All the changes were usually informed by the government-sponsored commissions of inquiry on education. Their recommendation reflected the aspiration of the country, having to raise adequate human resources to build the country. The role to be played by science has led to many reviews to help improve the quality.

Localisation was accompanied by a change to the 7-3-2 cycle of schooling, thus the BGCSE curriculum was offered in the last two years of senior secondary schooling. Due to limited spaces at senior secondary, only about half (51%) of the learners who started primary school study BGCSE. All learners proceeding to senior secondary take one of the single, double and triple science streams. Teaching in all the streams was supposed to have been done differently. Learner-centred approaches were to be used as opposed to traditional teacher-centred approaches. This study intends to find out what is happening inside classroom following the introduction of a localized chemistry curriculum and its intentions. Having discussed the education setting in Botswana, it was now important to give a literature review that relates with this research study.

CHAPTER 3 LITERATURE REVIEW

Introduction

The chapter commences by using the literature to establish a framework for the study. Rogan and Grayson's (2003) theory supported by the idea of situated cognition is the chosen theoretical framework. The theory (Rogan and Grayson, 2003) encompasses 3 constructs and the important notion of Zone of Feasible Implementation (ZFI).

The concept of ZFI which formed the core of the theoretical framework for this study is discussed. The literature was also searched for indications of how the ZFI could be located and what its usefulness to curriculum might be. According to the Rogan and Grayson's (2003) theory, the efficiency of curriculum implementation can be ascertained through the sub-constructs and assigning levels of operation.

The theory of situated perspectives also formed part of the study's theoretical framework. Teachers' communities and settings in their schools were discussed and linked with how the teachers eventually implemented the chemistry curriculum.

The literature was also reviewed for historical perspectives on curriculum reforms in science education. This highlighted the problems associated with existing curricula, teacher readiness and implementation. Teachers were considered central to this study and literature showing the importance of teacher cooperation in curriculum reform. This includes previous studies of teachers' knowledge of subject matter and pedagogical content knowledge (PCK) and how this might affect the way they implement a curriculum.

Rogan and Grayson's (2003) theory of curriculum implementation which makes it possible to identify the ZFI is discussed first.

3.1 The Theoretical Framework

The framework was chosen because of its relevance to curriculum implementation especially in science education and developing country contexts (Rogan & Aldous, 2005; Aldous, 2004; Rogan, 2007).

3.1.1 Constructs of the Theory of Curriculum Implementation

The theory of curriculum implementation (Rogan and Grayson, 2003) creates a detailed picture of factors surrounding the innovation processes in schools. It consists of three main parts referred to as constructs, summarised diagrammatically below. The constructs are (i) the profile of implementation, (ii) the capacity to innovate and (iii) outside agencies.

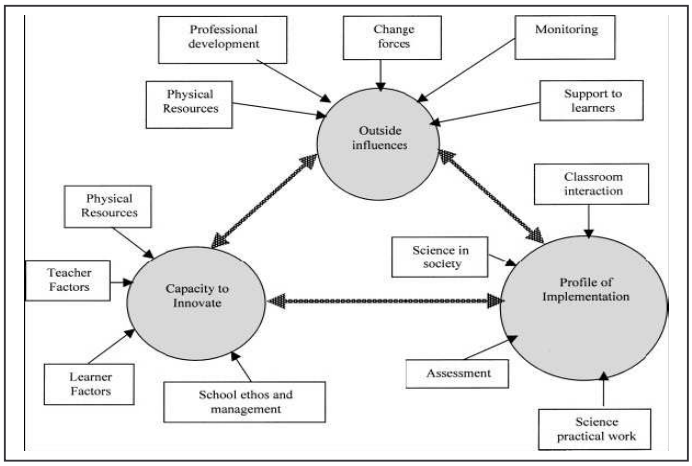


Figure 3.1: The framework on which the research is based (Rogan & Grayson, 2003)

The figure shows the three constructs, their sub-constructs and linkages. It is believed that links to sub-constructs might influence practice. For instance the profile of implementation (taken as the desired outcomes) shows how the intentions purported in the curriculum are manifesting in practice in the form of classroom interactions, science practical work, assessment and science and society.

The other two profiles, 'capacity to innovate' and 'outside influences' show how contexts of schools may support or inhibit implementation of a curriculum. Links like these have been shown to be very important in recent curriculum implementations as previous reforms were mostly concentrated in the quality of work put into designing the innovation but not on how it was implemented (Stenhouse, 1975; Hord, 1987; Havelock & Zlotolow, 1995). Rogan and Grayson's (2003) model shows vividly the overall build-up that is needed after the design of an innovation. It could be said that the profile of implementation gives a concrete description of what takes place inside the classroom. The secondary part of the model, the construct, 'capacity to support

innovation', outlines a number of indicators for the implementers that are internal to the school that may affect implementation. The last part of the model consists of a number of pointers to which those who intend to change a curriculum should pay attention.

First the profile of implementation and how it relates to this study will now be elaborated.

Profile of Implementation

The profile of implementation expresses the types and extent to which the ideals of a curriculum are being put into practice. In this case this would be a chemistry curriculum. According to this framework, process changes occur in four sub-constructs, shown in figure 3.1. Identifying the profile of implementation is crucial for this study because it offers a map of the learning activities that go on inside the classroom, constituting the nature of interactions coming from learners, the types of engagement in hands-on and communicative discourse in line with modern views of teaching and learning (Scott & Mortimer, 2003; Lave & Wenger, 1991). In recent years science educators have suggested various directions for improving classroom learning. For example, science instruction or classroom interactions should present learners with scientific knowledge in more authentic contexts (Roth, 1995). To encourage meaningful learning there is a need to encourage learners' discussions, argumentation, social negotiations skills, and cooperative learning (Newton et al., 1999). The execution of sub-constructs is separated into what Rogan and Grayson call levels of operation. High levels of these interactions correspond to top level 4 in the Rogan and Grayson (2003) scale of profile of implementation (Appendix A).

Practical work also forms an important part of the type of classroom interactions investigated, as chemistry is a practically oriented subject. The types and nature of practical work going on as well as the nature of engagement by learners constitute what might be regarded as good practice and learning (Pekmez et al., 2005). According to Lave (1996) and Wenger (1998) participation in modern learning can be equated to learning. Through participation, chemistry practical work is seen as having potential to help learners develop problem solving skills and apply scientific knowledge in solving everyday problems (Hofstein & Kesner, 2006). The profile of

implementation also accommodates other classroom activities such the incorporation of science and society which is an important component of the BGCSE curriculum (Motswiri, 2004). Involving science and society in instruction, is generally viewed as helpful in enhancing learners' process skills, creativity, scientific attitudes, decision making, and epistemological views about science (Hofstein & Kesner, 2006; Tsai, 2001; Yager & Tamir, 1993).

The second construct, 'capacity to innovate', will now be discussed.

Capacity to Innovate

Mapping out learning activities becomes important as there is an assumed link between degree of implementation and contexts of the schools (Rogan and Aldous, 2005; Hord, 1987). Hence mapping up current practice and contexts would help to understand and elaborate factors affecting classroom activities such as teaching and learning. Capacity factors are broad indicators coming from physical resources, teacher and learner factors, as well as the school setup. These are crucial structures in determining what leads to effectiveness in learning, but such factors can also act as hindrances to implementation. For instance, a well resourced school is in good position to support learning activities, whilst an impoverished school only has modest chances (Loucks-Horsley et al., 1998; Levin & Lockheed, 1993). Work and study conditions of teachers and learners, language of instruction, school ethos which includes functionality of school and leadership patterns, can easily influence the extent of teaching and learning (Berman & MacLaughin, 1977; Hord, 1987; Kelly, 1999; Garegae, 2003). These broad areas depict the importance of well developed capacity in carrying quality teaching and learning. It has already been stated that curriculum implementation depends on support from 'outside agencies'.

Support from Outside Agencies

Provision of resources is crucial to learning and functionality of the school (Hewson, Kahle, Scantleybury & Davies, 2001). According to their study, one of the main indicators of access to quality science education was identified as the availability of resources and teacher support. A positive support base to bring a favourable climate in school is critical as an unfavourable climate interferes with learners' opportunities to learn. It has been observed that negative environments may lead to learners

disengaging from school and learning (Hewson et al., 2001). The support they referred to is offered in the form of material things such as human resources, buildings, books and apparatus (Motswiri, 2004; Garegae, 2003; Koosimile, 2002; Hewson et al., 2001). Material support is also extended to learners in the form of provision of accommodation and meals. Non material support can also be viewed as taking the form of in-service professional development and monitoring of the implementation. Brown and Schulze (2002) talked of human resource support bringing a good environment for the health and welfare of the institutions.

However, the most important feature of Rogan and Grayson's (2003) framework is their idea of a Zone of Feasible Implementation (ZFI) which is relevant to this study. Identification of a ZFI is a key feature since according to Rogan and Grayson (2003), schools differ in many important aspects, bringing in the need to treat each school differently. Its identification allows for different approaches when a new curriculum is introduced. To understand the ZFI concept, it is important to first look at what Rogan and Grayson (2003) call the levels of operation.

Operational Levels

Rogan and Grayson (2003) attempted to categorise practice, capacity, and support in stages called levels of operations, progressing from lower to higher levels of development. Levels of operation are identified by the level of development of practice going on in a particular situation. The use of levels becomes clear based on these, the likely effectiveness of future interventions can be indicated. The implications are that the higher anticipated levels of practice, capacity or support with time, become the actual or current level in the future.

Hewson et al. (2001) also found the notion of levels useful in identifying readiness for, and progress toward reform. Working with smaller bits is similar to the notion that learning is possible if the more complex structures are based on simpler structures and also that a natural relationship and development of structures and not simply an external reinforcement, have greater impact (Hewson et al., 2001; Sadovnik, Cookson & Semel, 2001). According to Rogan and Grayson (2003), different schools and teachers have irregular starting points in terms of physical resources, school environments and even classroom practice (see fig. 3.2). Varied operational levels

between schools make it problematic to bring pre-specified remedies since the framework does not advocate a 'one size fits all' approach (Loucks-Horsley et al., 1998; Kelley, 1999). As a model designed for developing countries, it makes it useful because there are many schools that are disadvantaged and under-resourced (Rogan, 2007; Motswiri, 2004). This brings the possibility that such schools could operate at level one in many facets. With schools that are near dysfunctional state, it is difficult to bring the same kind of expectations as for those already functioning well.

3.1.2 The Zone of Feasible Implementation

The theory of curriculum implementation by Rogan and Grayson (2003) is part of the chosen framework for the study can be summed up as being guided by what they called the zone of feasible implementation (ZFI). According to the ZFI concept, schools differ, bringing in the need to allow for differences in degrees of implementation.

The ZFI (Rogan & Grayson, 2003) relates to the idea of Zone of Proximal Development, ZPD (Vygotsky, 1978). Vygotsky referred to new learning occurring in what he termed 'The Zone of Actual Development'. He identified this as learning a child can only achieve with the assistance of an expert or a capable peer. He referred to this assisted learning as taking place in 'The Zone of Proximal Development'. The gap between the actual and proximal development depicted what he called ZPD, which showed the extent of potential growth that can occur. The concept of a ZPD has powerful implications for teaching and learning for learners, teachers and curriculum development. According to Wertsch (1987), learners are able to perform tasks beyond their actual development levels. He observed that mediation by an expert or a capable peer led to learning to different degrees. The implications are that the current ZPD level with time becomes the actual level in future.

Determining the ZFI

Examining a science curriculum innovation using the idea of a ZFI involves doing more than just establishing that the curriculum implementation is in fact happening. The ZFI could be described as the gap that exists between the current practice and

desired curriculum intentions. The figure below attempts to capture the concept of the ZFI in relation to current practice.

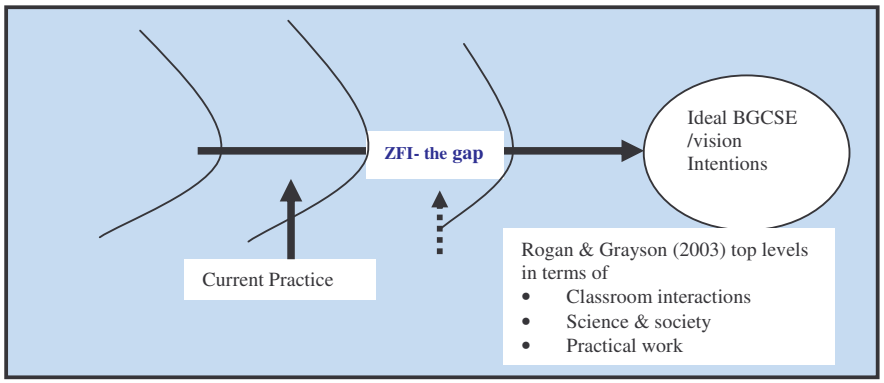


Figure 3.2: The gap between current and ideal practice

One view of the ZFI is that it is a gap within a practice when the activities within current practice are not yet fully developed. It can also be viewed as the gap existing between current practice and the next level. According to Rogan and Grayson (2003), the gap

> …is a zone of feasible innovation. Innovation is most likely to take place when it proceeds just ahead of existing practice. Implementation of an innovation should occur in manageable steps (pg 1195)

The implications are that educational innovations requiring large leaps that fall outside the ZFI's of a school are thought to be unlikely to cause any effective change, just as teaching of new ideas outside the learner's ZPD are ineffective (Rogan, 2007; Rogan & Aldous, 2005; Vygotsky, 1978). According to these ideas, a school's current development level, equivalent to Vygotsky's level of actual development should be determined in order that the current strengths could be enhanced while retaining the good practices and ideas from lower level (Rogan & Aldous, 2005). The notion of ZFI can be viewed as useful, because of the notion that for every school, there is a next step for development.

Identifying current practice in a school makes it possible to identify the ZFI of that school. A summary of steps to identify current practice in a school coming from various sources points towards the following (Rogan & Grayson, 2003; Loucks-Horsley et al., 1998):

- A creation of a vision of what the school system should look like
- Making a compilation of the current situation e.g. from any of the three constructs (Rogan and Grayson, 2003)
- Identifying strengths and weaknesses of the current system in light of the ideals
- Target priority items for improvement in line with what appears achievable
- Establish a plan for addressing these priority items, finding a way to gauge success
- Assess progress regularly and revise actions as needed
- Take stock again and use feedback to revisit vision and begin cycle again when the action cycle is completed

In this study, the vision of what the school system should be, was considered to be the ultimate goal of the BGCSE curriculum (Republic of Botswana, 1994). Close scrutiny has revealed that the demands of the BGCSE correspond with the higher levels of operation in the Rogan and Grayson scale (2003). The ideals of the curriculum are considered the yard-stick, against which current practice was measured.

Usefulness of the ZFI as Part of the Framework

The ZFI as the key feature of the framework for this study is useful because of its ability to identify knowledge base for growth, measure or guide success. Identifying the gap can be the target for improving the change processes or areas within the sub-constructs that are still low. Accordingly, the ZFI offers a useful consideration when analysing implementation. Guidance by the framework makes it possible to guard against adopting the implementation universally because movement from lower to higher levels of implementation differ. This becomes clear to see because of the various factors at play such as related to capacity to innovate profile (Rogan & Aldous, 2005; Rogan & Grayson, 2003). Due to these differences, the amount of change required by a school to move from one level to another are not expected to be the same.

In all the three profiles (fig. 3.1) it is possible to grade the level of curriculum implementation, support or the capacity to implement a curriculum. Two diagrams will be used to illustrate how the degree of curriculum implementation, capacity or support rendered to implement the curriculum could be determined. According to

Rogan and Grayson, the four levels of operation can be used to explain the three constructs.

Four levels ranging from 1 to 4 and increasing in sophistication have been defined for each sub-construct. Using the profile of curriculum implementation as an example, the increase in sophistication shows a progression from teacher-centeredness to more learner-centred orientation to teaching and learning (Rogan, 2007). At higher levels, also depicted in figure 3.3, learner activities become more open-ended and investigative in nature (Abdl-El-Khalick, Boujaoude, Duschl, Lederman, Mamlock-Naaman, Hofstein, Niaz, Treagust & Tuan, 2004; Motswiri, 2004). The highest level of operation shows the kind of practices envisaged by the new Botswana curriculum (Motswiri, 2004). Figure 3.3 below shows the development of level of implementation in classes as envisaged by the theory.

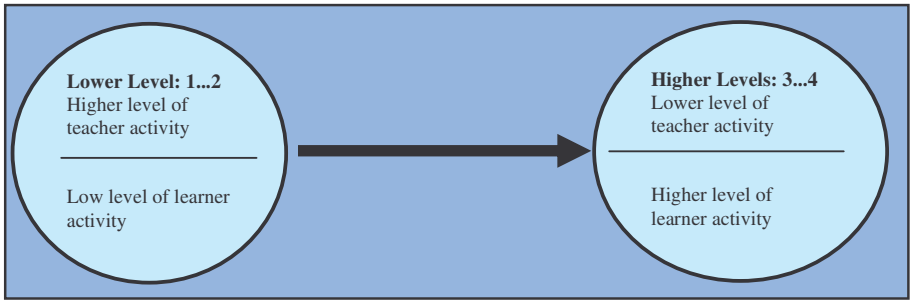


Figure 3.3: Developmental levels of implementation (adapted: Rogan & Grayson, 2003)

Unlike other profiles, higher levels of practice still incorporate practices from lower levels and do not replace them. The other two profiles, 'the profile of capacity to support innovation' and 'outside agencies'' level 1 can be visualised as a school with low level resources, poorly qualified teachers and dysfunctional administration. A move to higher levels shows schools with a better capacity to implement a new curriculum. An example of how the dimension can be manifested in a particular school has been illustrated in figure 3.4.

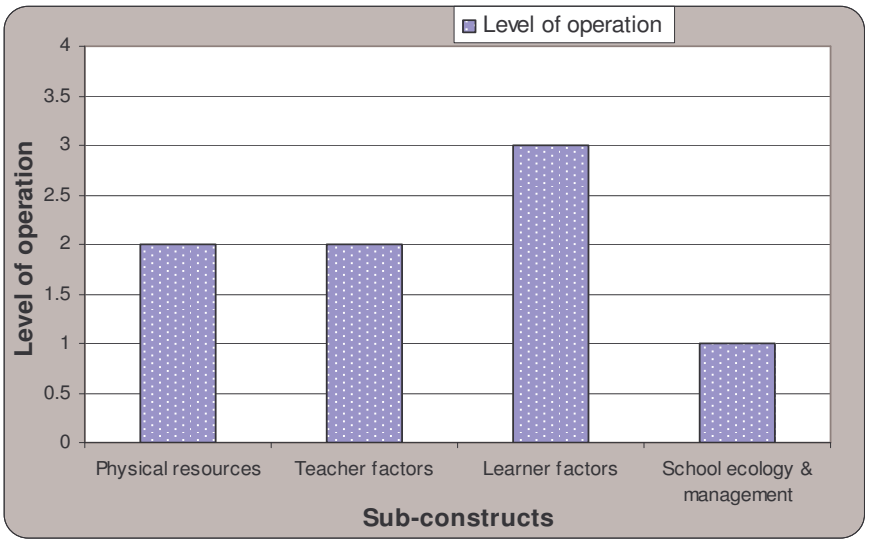


Figure 3.4: Indicators of Capacity to support innovation

Figure 3.4 represents a school with physical resources matching Rogan and Grayson's (2003) level 2. Such a school would be considered to have resources indicated under practice below and what would be need to be acquired, if level 4 is attained,

Rogan and Grayson (2003): Level 2
Good building; enough classrooms; a science room; sufficient science apparatus
Electricity in all rooms; running water
Textbooks for all pupils and teachers
Secure premises
Well kept grounds

(Current Resources)

Rogan and Grayson (2003): Level 4
Excellent buildings; well equipped science laboratory; library or resource centre; Adequate curriculum materials; good teaching and learning resources such as computers, photocopying facilities, models for science teaching; Attractive grounds

(Ideal Resources)

Figure 3.5: Excerpt from a school and Appendix A showing physical resources

Looking at figure 3.4, it is possible to see that these factors coming from different sub-constructs may affect schools differently, but adopting the principle of differentiated implementation which is core to the ZFI concept seems the answer (Hopkins and MacGilchrist, 1998; Loucks-Horsley et al., 1998 and Kelly, 1999).

Following identification of the level of the school's capacity, phased implementation can be adopted to give chance for capacity to grow in areas that are underdeveloped, for instance, towards level 4. As a guide to implementation, it becomes important to know which factors have greater impact in a school. In such a situation, support and pressure strategies can be aimed at other areas to enhance implementation. This

implies that instead of just looking at the physical resources as the area leading to improving teaching and learning, focus can also be shifted to others sub-constructs to bring in desired outcomes. Another important aspect brought into focus by the ZFI is that, instead of aiming to reach level 4 from level 2, the school's ZFI would be within level 3. Accordingly, it would be easier and more realistic for this school to aspire to reaching level 3 than level 4 when resources are still lower. It would also not be realistic for a school with such resources to be expected to aim for level 4 in terms of profile of implementation sub-constructs.

3.1.3 Situated Perspectives

Another part of the framework of this study is the idea of situated perspectives. Lave and Wenger (1991) viewed learning as participation in a community of practice. Hence learning to do new things is about becoming a better participant in that community. According to the theory of situated cognition, learning becomes a communal rather than an individual activity. It is also important to note that situated learning is situation specific, situated in the context that it occurs, (Brown, Collins, & Duguid, 1989). Such setups therefore encourage collaborative activities as they are seen as potential sources of knowledge (Brown & Schulze, 2002; Thijs, 1999).

According to Brown et al. (1989), knowledge is situated, being in part a product of activity, context and culture in which it is developed and used, so learning involves being part of the class or department and taking part in learning activities. According to situated perspectives, knowledge becomes a set of practices of inquiry and sense making that includes communication, questioning, and understanding, explaining, and reasoning (Brown et al, 1989; Brown & Schulze, 2002). Hence learning in general is gauged by increased participation in an expanding range of such practices. This view does not place emphasis on content only, but considers the purpose of learning about participating and building identity in a community of practice. For effective learning, value is thus placed in increasing participation in a community which could be a chemistry class for learners or participation in working together by chemistry teachers. According to this perspective, lack of opportunities to learn is associated with learners' or teachers' minimal participation in learning activities. This could also be interpreted to include the incorrect use of tools, resources, teaching strategies or

non-engagement in teaching setting. Due to focus on co-participation, it could be argued that by non-participation, learners can not proceed from being novices to masters.

Lave (1996) has extended social constructivism into a new learning theory. For instance social constructivists argue that knowledge is constructed inter-subjectively involving others whom the teacher can influence. According to Lave (1996), there is more to learning than acquiring concepts, skills and procedures. An extension of this theory was made by Lave and Wenger (1991) when studying apprenticeship as a learning model. According to them, the apprenticeship relationship is usually visualised as that of learner-master. Further studies by Wenger revealed more complex social relationships through which learning takes place (Wenger, 1998). The term community of practice coming from studies that looked at influence of relationships on learning can have practical use in education set-ups, such as in teacher training, schools and classrooms. Peer-to-peer learning activities are typical in a basic community of practice. The activities of the community of practice become more important than the activity of the individual.

Position of the Teacher in Situated Practice

The teacher is viewed a co-participant in a community of practice. Wenger gave an example of teachers who meet regularly in staffroom for tea creating discussion opportunities (Wenger, 1998). Such setups are claimed to become the teachers' important source of knowledge about how to teach, deal with situations in classrooms or issues surrounding work in general. Such a theory of learning in practice could be used to gauge, explain as well as account for the type of interaction occurring in schools and the level of implementation occurring in various schools.

3.1.4 Amalgamating Rogan and Grayson's Three Constructs

The usefulness of the frameworks becomes apparent when one looks at how the Rogan and Grayson's constructs interact. That is, how the three are affecting, influencing or impacting each other. For instance, when classroom activities are not linked to the contexts at play, according to this framework the curriculum implementation becomes trivial. Hence, it is important to know effects of factors

coming from capacity to support innovation and to some extent factors from outside agencies to garner proper resources for a balanced implementation. Links can be made in the following areas:

- Capacity development versus profile of implementation: there is need to develop capacity that is context specific, with the view to enrich implementation; capacity and implementation informs position of ZFI and level of support.
- Outside agency support versus profile of implementation and capacity factors – profile of implementation should be context specific, expectations should mainly be guided by the capacity existing in a particular school, but the degree of support to develop capacity should also be guided by both current level of capacity and implementation.
- Re-conceptualisation – teachers (schools) need to look at themselves (their contexts) as to whether the changes they make are in their own terms and contexts (Loucks-Horsley et al., 1998).
- Alignment or discrepancies existing of the three construct in the schools (what is the primary focus as viewed by teachers).

The above points will now be expanded:

The purpose of identifying the ZFI for a school is to ensure that the gap of implementation is not too large for a particular school to cope with. If the gap is small, it is possible to improve to the next challenging level. The idea of levels of implementation was employed to investigate the current practice against the intentions of BGCSE curriculum's developers. Since different teachers of differing teaching experience and schools of different era (new and old) and even from various regions were selected, it was vital to use the other constructs to illuminate sources of variations that might exit or predict influencing factors. According to Rogan and Grayson (2003):

> Capacity to Support Innovation needs to be developed concurrently with efforts to enrich the Profile of Implementation (pg 1196)

It was therefore vital to find the contextual situations in Botswana senior secondary schools, which is how capacity factors in the selected school influenced implementation or how implementation over the years had influenced capacity. There is a view that there is need to garner resources to develop capacity where it is lacking

to help push implementation (Hewson et al., 2001), thus widening the current operational level. But over growing capacity with low operation level can lead to a situation of giving too much effort or resources with little gains if not properly planned (Rogan, 2007; Hopkins & MacGilchrist, 1989).

Identification of the ZFI is viewed as important to outside agents in guiding the amount of support individual schools need. For instance knowing the level of operation in terms of implementation and capacity in terms of resources can help gauge areas of need to raise capacity. According to the framework, support should be informed making it necessary to also know how capacity influences the extent to which implementation occurs. For instance in Botswana secondary schools where there appear to be more chemistry related resources than the laboratory work going on in classrooms, there might be a need to run a workshop for teachers on laboratory work. The same could be said about provision of more resources in schools, there is need to look at the level of implementation and capacity before more materials are given to schools.

Various authors have talked about the need to conceptualise changes according to schools' own terms guided by own context (Rogan, 2007; Hattingh et al., 2007; Hopkins & MacGilchrist, 1998; McLaughlin & Marsh, 1978). Re-conceptualisation of innovation means new meaning is recreated by the implementers that make sense to the implementers, as well as being achievable in their own eyes (Fullan, 1998, Tsai, 2001). This assumption is in line with radical constructivist views that individuals create their own knowledge as recreation allows implementers to explore and judge the innovation's classroom effects (Tsai, 2001). By gaining evidence of change, the teachers are more inclined to try that more or even build on the changes (Hopkins & MacGilchrist, 1998; Fullan, 1998; Hargreaves, 1992). This is achievable when the three constructs are concurrently considered during implementation.

The situated perspectives were considered crucial due to its link with participation and community of practices. Situated perspectives have powerful ideas to look at issues of implementation, teaching and learning and collegiality in chemistry education. Where there is non-participation, there should be no learning as individuals construct new knowledge through participation (Sfard, 1998). This could be through answering

teachers and learners' questions, explaining and raising chemistry questions or issues to others. The community in which the teacher is embedded is therefore important for the general teaching and learning and consequently implementation of a curriculum.

Community of Practice as a Link between the Three Constructs

Teachers were considered central to this study. They are responsible for transforming the ideals of the curriculum into practice. Hence, they will be used to make a link between the theory of curriculum implementation and the situated perspectives. Study by Brown and Schulze (2002) has documented aspects of a community of practice by teachers such as mandatory, interest and prerogative influenced by a community of practice of teachers and the interplay of the micro-politics where the teachers are embedded as responsible for relationships that shapes interest and eventually raise performance at work. The relationships that teachers create and sustain with colleagues in schools are viewed as very important. According to Brown & Schulze (2002) such relationships are often overlooked in many reform efforts. According to them, when healthy working relationships can be sustained it becomes a mutually rewarding relationships as it can enrich the lives of those involved in curriculum implementation through an increase in productivity. This has implications for the widening of the ZFI. Hence, the community of practice by teachers is viewed as key in uniting the situated perspectives to the ZFI. An attempt has been made to capture this link on figure 3.6.

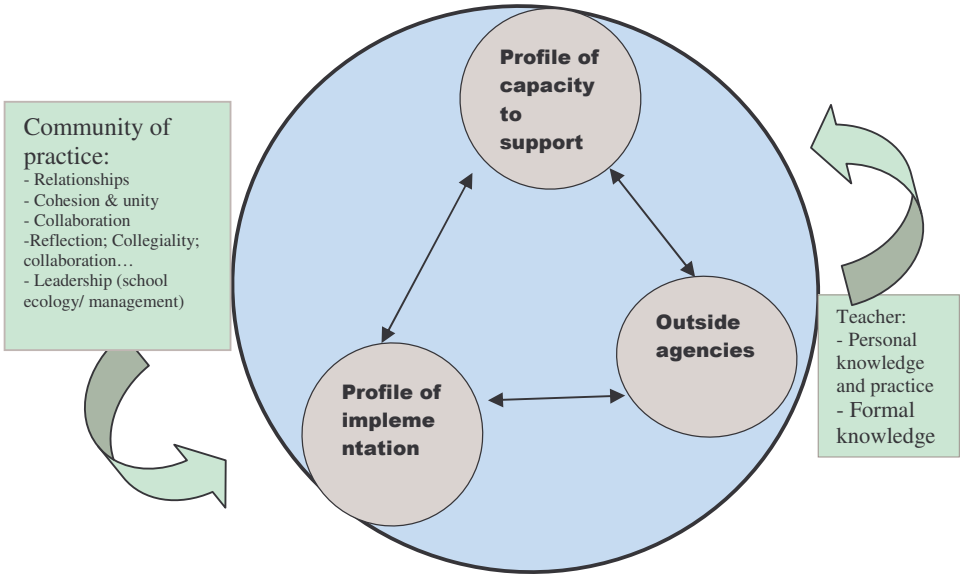


Figure 3.6: The teacher's community of practice linking the theory of curriculum implementation and situated perspectives.

Another aspect of theory of curriculum implementation is that curriculum implementation is context specific. This makes the ZFI important because it is situation specific.

3.2 Other Literature Relevant to this Study

This section will now discuss further reviews which served to guide this study such as: studies of previous curriculum reforms in science education and some empirical studies relating to effective and contextualised chemistry teaching. Papers researching learning such as constructivist-based studies, and theory on practical work will also be looked at. First studies of curriculum reforms will be discussed.

3.2.1 Other Studies on Curriculum Implementation

The theory of curriculum implementation by Rogan and Grayson (2003) can be said to have came from a summary of a number of developmental models for schools with the intention of taking diversity of schools into consideration. The model consists of a wide-angle lens, scanning the fields of curriculum reforms, teacher professional development in science and mathematics education over the years, noting what has changed and what has not over time (e.g. Beeby, 1966; Loucks-Horsley et al, 1998). This framework is particularly suitable as it targeted developing countries and it was devised in the region. It is particularly relevant due to major curriculum changes, for instance the Curriculum 2005 (C2005) of South Africa and the BGCSE curriculum of Botswana. The model attempted to take into consideration the realities found in the countries' schools.

Rogan and Grayson's (2003) theory of curriculum implementation exemplified the actual trends of implementation by dissecting previous designs on developmental and educational innovations. There are examples of similar models such as the one by Beeby (1966) which attempted to categorise schools in stages, progressing from lower to higher levels of development. The theory of curriculum implementation model is also based on more comprehensive models proposed by Verspoor and Wu (1990) and De Feiter, Vonk and van den Akker (1995). Their model attempted to broaden the

focus of curriculum development and implementation, touching on factors relating to the teacher as an implementer and the schools' contexts.

Such models were found to be problematic due to the notion of distinct stages which according to Guthrie (1980) ignores the complexities of an educational system. For instance, the focus was more on teachers, overlooking other facets of school contexts and thus limiting its applicability. The later model by Verspoor and Wu (1990) and De Feiter et al. (1995) had flaws too as it was observed that they ignored learner factors. Critiques of the model by De Feiter et al., (1995) pointed to its continuous nature, as it envisaged development as a progression towards the higher and more sophisticated phases. Schools are diverse, which means different developmental stages will be experienced at any given point of implementation due to factors surrounding different schools.

Recognising diversity of schools calls for consideration of differences by adopting a phased approach. It could have been predicated that due to the vastly different school contexts existing in the South Africa, a complicated innovation like C2005 would be difficult to implement in one step. In South Africa, Johnson et al. (2000) have suggested that introducing a new curriculum in smaller bits would allow teachers to master the less demanding innovations within their own comfort zone. The hope was that this would prepare them for further changes as they gained confidence over time. This should also be true for curricula in the SADC region such as the BGCSE curriculum of Botswana. A differentiated approach has the potential to allow for relevant professional development programmes to be offered. Research shows that in Southern Africa there has been a general tendency to ignore existing contexts, by promoting a one size fits all approach. Such approaches are usually dictated by mandates which focus mainly on what is intended for all schools rather than what is feasible in a particular situation (Rogan, 2007; Rogan & Aldous, 2005; De Feiter et al., 1995).

A differentiated approach to curriculum implementation and professional development is not new. It was suggested by Hopkins and MacGilchrist (1998) in their study of a project implemented in the UK. Their approach basically proposed a three pronged approach to curriculum implementation. The lower and less

sophisticated strategies were aimed at low performing schools, to help them reach some level of success. This was done with the view of placing them on course for functionality. The guiding principle was that the target goals were within achievable reach for any particular school. It was believed that reaching target goals would instil confidence in the teachers and set them up for operating at higher levels. Higher level strategies were targeted at moderately successfully schools, aimed at helping schools improve areas of competence. The highest level had strategies that were for schools already operating at quality levels, aimed at introducing more sophisticated teaching and learning methods. This highest level could be equated to the desirable levels of operations intended by the new curriculum in Botswana.

The framework for curriculum implementation put forward by Rogan and Grayson (2003) takes on board the views of Beeby (1966), Verspoor (1990) and De Feiter et al. (1995), which consider different contexts. It also uses the ideas of Levin (1987) and Loucks-Horsley et al. (1998) who advocates building on strengths rather than focusing on remediating weakness. This approach therefore diminishes the concept of linearity, something considered a weakness. Linearity is considered a weakness because movement to higher phases means lower stages or practices is ignored. Building on strengths requires identification of current conditions or practices coming from the teachers, learners and school environments.

The three pronged styles appear to be the right approach to follow when implementing a new curriculum when there are diverse contexts as was found in schools in South Africa (Rogan & Aldous, 2005; Rogan, 2007). A high outcome in education projects has been observed where training was made appropriate for the teachers by tailoring the training to their specific contexts (Kelly, 1999; Verspoor, 1989; Hopkins & McGilchrist, 1989). Though apparently desirable, such an approach has not been favoured during curriculum implementation, even in recent years (Rogan, 2007). For governments, the most appealing approach to curriculum reforms have been the less interactive modes, due to the logical sequence of actions and cost effective nature of the interventions (Stenhouse, 1975).

This is in contrast to what is advocated by the concept of ZFI, which says that approaches of how to bring about changes in schools should differ, as schools are not

all the same (De Feiter et al., 1995; Kelly, 1999; Johnson et al., 2000; Rogan, 2007). Recognising differences is in contrast to popular assumptions that all schools are the same. This belief usually becomes evident when schools are given the same innovations to implement and expectations to be met. Change processes are context specific and will play out differently in different schools (Fullan 1998, Kelly, 1999). The theory of curriculum implementation by Rogan and Grayson (2003) seems to have attempted to address the issues of concern from previous models of curriculum implementation.

More reviews will now be explored, dealing with curriculum reforms in general.

3.2.2 Studies of Curriculum Reform

Curriculum reforms have in the past been faced with problems. Most of the problems can be linked to lack of understanding of how innovation and implementation work. According to Hord (1987) the perspective held in the past was that once an innovation was formally adopted, it should automatically flourish in daily practice in schools (Hord, 1987). Despite well thought out innovations, problems of continuous failure to gain good results persisted as developers were using frameworks that were not relevant.

In general problems can be traced in large measure to fundamental ignorance concerning implementation processes. This was mainly due to knowledge acquisition perspectives aligned to scientific methodologies and ways of knowing which where the dominant paradigms at the time. Examples of such positions are found in the US and the UK, where new programmes at the time were not implemented as their developers intended. The programmes were therefore constantly reviewed and replaced (Hord, 1987). Association of failure for innovations to take off with poor program design led to the frequent changes as results from reviews usually failed to reveal any significant gains in students' performances (Hord, 1987; English & Larson, 1996; Ornstein & Hunkins, 1998).

A number of conceptual models of change have been created covering a broad spectrum of possible approaches which seemed to lean towards underlying the philosophical positions of their writers (English & Larson, 1996; Ornstein & Hunkins,

1998). Some of the models which were found to be useful in the past, mainly focused on the delivery of an innovation to schools and getting it adopted (Hord, 1987; Ornstein and Hunkins, 1998). Though education was viewed as a people oriented endeavour, attention paid to human and the interpersonal aspects of change were limited. The primary emphasis on innovation (change) as a product meant the personal and psychological considerations were left out as they were seen as potential impediments to accomplish the end. Examples of such positions included the empirical-rational approaches by Chin and Benne (1969), social interaction models of change by Havelock (1973; 1977) and research development and diffusion (Havelock, 1973; 1977). Their ideas were firmly rooted in the enlightenment-based liberal arts tradition that people are rational and therefore that they can be appealed to or persuaded by their fellows on rational grounds to implement change. According to this position, teachers and schools should adopt any given change if it can be justified and shown to be in their own best interest (Hord, 1897). Since change was build around a host of experts with their specified skills, the process was methodological, thriving in an orderly fashion of problem identification, production of appropriate solution and eventually dissemination (Hord, 1987; Havelock & Zlotolow, 1995; Ornstein & Hunkins, 1998).

Such models of change have faced challenges when adopted because of situations found in different countries such as resources and capabilities to diffuse and implement, leading to differences in response rates (Hord, 1987; Lewin, 1985; Rogan & Grayson, 2003). Expertly designed and disseminated innovation products were not expected to face problems, but in practice such models were found to take a narrow view of innovation (English & Larson, 1996). The assumptions were, if the innovation product was good, the development efforts of so many experts ought to ensure that it was adopted. The role played by various other players such as the teachers was neglected as they were passively viewed as receivers in curriculum implementation.

Another group of models employs a different conception of what change is and how to go about achieving it (Ornstein & Hunkins, 1998; Havelock & Zlotolow, 1995). This approach essentially attempted to make schools better by improving the individuals working within them in a bid to help the institution to improve itself. The

conceptual framework within which the models operated, represented a radical shift in emphasis of the logical rationalistic arguments associated with product-delivery conception of innovation. Focus was now on the views of humanistic psychology which stressed non-hierarchical, personal interaction and maximum communications (Ornstein & Hunkins, 1998; Havelock & Zlotolow, 1995). In such setups, all participants such as teachers and curriculum experts were to be active in all phases of change. Recognition of importance of social values and practices as opposed to purely rational considerations came from the recognition that values, habits and other normative structures and roles as well as rational responses to new information were vital to change process (English & Larson, 1996; Kelly, 1999).

More humanistic approaches viewed problems as more likely coming from the attitudes, values or norms of the various relationships within the institution. Following the humanistic route of curriculum reform required less need to have prior input from experts. Considering relationships had the potential of uncovering and examining previously unrecognised impediments due to the reconstruction of values that could potentially be induced. The intention was to successfully embed the process of personal growth into the system, with the view that a positive ongoing process of growth and improvement would follow (English & Larson, 1996; Havelock, 1995). Such an approach has had influence in the formulation of science curricula in developing countries.

There is often great optimism that science education will play a crucial role in national development. For instance, Lewin (1992) and Lewin & Hui (1989) reported of an era of educational reform that occurred as a result of a change in the political climate in China. In China the reforms brought a commitment to a compulsory 9 year cycle of schooling, the rapid introduction of technical and vocational schooling, changes in curriculum and pedagogy. Such changes were brought about because of the belief that education could help raise the national economy and solve political problems, and also a realisation that education was key to modernisation. There was an association between educational development with economic development as well as compulsory education with social progress. Such reforms had an impact on the schooling system as there was concern for quality, access and equity and in the social reconstruction of the nation (Lewin, 1992).

Optimism about national development through education was also found in South Africa. National development has improved significantly since the end of apartheid (Rogan & Grayson, 2003; Johnson et al., 2000). The main focus for education was to devise policies which addressed the issues of social demands for education, open access and especially the equitable distribution of educational resources in the SA context. Lewin (1990), observed that there was a growing trend in developing countries that a large proportion of their labour force will be employed in non-agricultural, scientific and technological industries. This had implications in the Southern African region as a move towards more electronic consumer products would possibly have been more important in fuelling growth. Such projections had implications on promoting reforms in the science education curricula in a way that reflects the changes in economy. The implication of Lewin's work in developing countries was that there was a need to plan science education in a way that is cost effective, efficient and equitable (Jansen, 1999; Lewin, 1992; Lewin, 1993). The curriculum was also targeted for the majority of learners rather than providing for the minority (Yager, 1986). C2005, an outcomes-based education (OBE) project eventually came and has since its introduction been reviewed (Rogan, 2007). OBE was a radical change from what Jansen (1999) had earlier perceived as a science curriculum that was foreign to a majority of learners. With introduction of OBE, the focus was now on what learners do with their knowledge rather than on the teacher's instructional input. Hence, in outcomes-based learning, a learner's progress is measured against that learners' performance on agreed criteria.

At about the same time as the development and introduction of a new curriculum in South Africa, the Botswana government was also working on a localised curriculum proposal to take over from the foreign Cambridge Overseas Certificate (Motswiri, 2004). The move came about due to growing concerns around effectiveness of traditional methods of teaching driven by content (Prophet & Vlaardingerbroek, 2003). The policy on science education and chemistry development are discussed in detail in chapter 2, but the gist of the curriculum statement was that it should be relevant and equip all learners with an understanding about scientific knowledge and skills that every citizen need to exist meaningfully in a society (Yandila, 1999; Prophet & Vlaardingerbroek, 2003).

Differentiating the BGCSE science curriculum into three streams seems to have helped in upholding the science for all principle as well as giving consideration to the fact that some learners will want to continue with the sciences at university, whilst others will not. These streams also catered for the formerly disadvantaged in the sciences like minority groups, girls and boys, rural and urban backgrounds (Koosimile, 2005a; Motswiri, 2004). According to the revised national policy on education, balancing this element was very important (Republic of Botswana, 1993). It became important to consider the global concern of preparing learners not only for educational careers, but also a background which Yager and Weld (1999) think will provide them with understanding of scientific knowledge and skills that every society and citizen needs.

3.3 Studies of Teaching-Learning Relevant to this Study

In recent years science educators have searched for better ways to help learners learn science (Reid & Hodson, 1989). Various directions for improvement of science education have been suggested, for instance presenting scientific knowledge through practical work (Hodson & Hodson, 1998), authentic contexts (Roth, 1995; Hostein & Kesner, 2006; Pilot & Bulte, 2006a), encouraging discussions, social negotiations and cooperative learning (Newton, Driver & Osborne, 1999). Science education was seen as having the potential to bring relevance to the learners if it helped learners develop problem solving skills and apply scientific knowledge in solving everyday life problems (Hostein & Kesner, 2006; Pilot & Bulte, 2006b; Gott & Duggan, 2007). In Botswana, there was also a call for chemistry to be presented to students not only as a body of knowledge but in a way that shows its manifestation and its influence on the students' life and the society in which they live (Republic of Botswana, 1993; 1997).

3.3.1 Science and Contexts

There have been calls for recognition of the importance of science education to prepare learners for future citizenry (Republic of Botswana, 1993; 1997; Yager & Weld, 1999). This in a way has called for making scientific concepts more relevant to learners. Relevance to the learners also meant taking into account what learners brought into learning environments (Hewson, 1996). There was a general belief in the

past that learners do not bring any valuable knowledge into learning situations, hence the predominance of teacher-dominated lessons. Accordingly, such environments reinforced transmission and rote learning approaches (Rowell & Prophet, 1990).

From the 1970's an alternative to transmission approaches has been a constructivist view of teaching and learning. Stemming from these views, the learner has become the focus for learning, actively participating in meaning making. Learners' knowledge, often referred to as having preconceptions is viewed as crucial to meaning construction (Hewson, 1996). According to social perspectives, learning to do science is also dependent on whether the created environments allow them to learn individually or as a group. To promote meaningful learning, science educators are urged to encourage instruction that allows for discussion and cooperative learning (Newton, Driver & Osborne, 1999). In order for such discourse to take place, learning needs to be mediated within proper contexts that support construction of new knowledge (Wertsch, 1985).

There is a great deal of evidence that contextualising science is generally helpful in enhancing learner's process skills, creativity, science attitudes, decision making (Swartz, 2006; Bennett & Lubben, 2006; Lubben, Campbell & Dlamini, 1996; 1997; Bulte, Westbrook, De Jong & Pilot, 2006; Hofstein & Kesner, 2006) and even epistemological views about science (Yager & Tamir, 1993; Gilbert, 2006).

Context-based education is embedded in a tradition that assumes that context is essential for learners' learning. In such a setup, learners need to find solutions to real-life problems by asking, refining questions, designing and conducting investigations, gathering and analysing data, making interpretations and creating explanations. Several context based approaches have shown the importance of social setups as well as contexts in meaning-making. For instance, the various research projects developed and attempted in different countries such as the Chemistry in Context (CiC) in the USA (Schwartz, 2006), Salters family for context-based chemistry, physics and biology in the UK (Bennett & Lubben, 2006); Industrial Science in Israel (Hofstein & Kesner, 2006) and Chemistry in Practice in the Netherlands (Bulte et al., 2006). These context-based movements find their place among large developments such as project-based, activity-based or inquiry-based education that attempts to make the learning of

science more meaningful for learners. For instance taking an example of such case projects in the US, UK and Israel will be briefly discussed.

The CiC project in the USA was designed in the late 1980s to address the need in undergraduate programmes for more chemistry tertiary students (Schwartz, 2006). The project was started by a team of university chemistry lecturers whose motive was to improve chemical literacy in America. Scientific literacy requires an understanding of evidence and its underlying ideas. This has implications in the understanding of public claims. Literacy knowledge is believed to empower citizens to challenge decisions with some confidence and engage effectively in debates, asking sensible questions (Gott & Duggan, 2002). Support materials coming from the project had been useful to learners in improving confidence in debates and arguments and to some extent improved attitudes towards science (Schwartz, 2006). The success of the course led to teachers following the programme as well as influencing tertiary-level courses in the US.

Another such project aimed at contextualising scientific content was the Salters Approach (Bennett & Lubben, 2006). All programmes are designed in such a way as to meet externally specified criteria in terms of scientific content and assessment systems. The Salters courses have been adapted and introduced in many other countries. For instance, studies by Lubben, et al. (1996; 1997) in Swaziland used this approach at junior secondary school and primary school levels. Context-based approaches used to train teachers, in teaching integrated science to learners and introducing STS teaching methods. Reports showed mixed successes both as a teaching tool inside classroom and as a tool for professional development to introduce STS (Lubben et al., 1995; 1996; 1997).

Another example was the industrial chemistry project started in the 1980s in Israel by Hofstein (Hofstein & Kesner, 2006). The goal of the project was to teach chemistry concepts in the context of industries at personal and societal level (Hofstein & Kesner, 2006). The learning materials provided an in-depth focus on an industrial plant, on how it impacted its immediate surroundings in terms of pollution and economy together with instructional techniques and pedagogical interventions. Hofstein and Kesner (2006) showed that the approach led to a great awareness by learners about the impact of chemical industries in their localities in terms of economic gains,

environmental and social impact. There were also reports of positive gains by learners in terms of development of various skills such as decision making process skills and science attitudes.

Generally all these approaches focused on the question of how to increase the congruence between outcomes of the conventional chemistry curriculum and what should be attained (Bulte & Pilot, 2006). These intended to bring what Bulte and Pilot (2006) call a meaningful connection between learners' learning of chemistry, and their daily life and societal issues. Such contexts represent a coherent principle based on what learners need to know linked to authentic practices. Sadly such practices have been found to be effective with students who are not concentrating on the sciences. According to Hofstein and Kesner (2006) and Schwartz (2006), traditional teaching is preferred as the effective way to prepare professional chemists. Emphasis on contexts was observed to have the potential to obscure rather than clarify chemical concepts and interfere with their generalisation and transferability to a range of content. They also observed from their studies that contextual approaches can easily result in omissions in the content of the chemistry, thus causing difficulties in subsequent chemistry courses. However, contextualisation is viewed as having great potential when the focus is not content only.

Practical work in Botswana was identified as central to achievement of learning of chemistry linking it to day-to-day life and social issues (Motswiri, 2004). Practical work will now be briefly discussed in the section that follows.

3.3.2 Practical Work

Practical work in science has evolved through a series of stages over recent years. According to Gott and Duggan (2007) there has been a tendency for most practical work to be illustrative in nature, characterised by a teacher demonstrating a concept or law, or by guiding learners to discover concepts or laws themselves (Hodson & Hodson, 1998; Millar, 1991). Central to this practical approach was arriving at the correct answer.

Practical work later involved more open-ended investigations which were still laboratory based tasks. Learners were encouraged to design their own investigations,

collect and interpret their data, though it was in more contrived contexts of just one or two (independent and dependent) variables. The new approach was due to concerns over the restrictive nature of previous types of practical work (Gott & Duggan, 2007). New curricula such as the C2005 of South Africa and the BGCSE curriculum of Botswana encourage teachers to include field work, use secondary sources of data and consider societal issues to understand and using evidence from practical work (Motswiri, 2004; Rogan & Aldous, 2005). It is clear that the aims of science education have grown, calling for exposure of learners to various scientific methods, making it necessary to employ a wider range of practical tasks. Decisions of which type of practical work to employ depend on their purposes. With a growing need for learners to understand how claims from experimental data come to be made, as well as the importance of factors considered in the design and collection of the data in determining the weight of the claims, there is more to practical work than just observing (Gott & Duggan, 2007, 2002; Pekmez et al, 2005).

Typical categories of practicals common at secondary school level are usually simple tasks with one independent and one dependent variable which has been the norm in the BGCSE curriculum and the diagnostic (fault-finding tasks) which are currently reserved for the elite science stream called triple science (Motswiri, 2004). A significant part of scientific literacy requires an understanding of evidence and its underlying ideas in order to understand public claims. The assumption of this idea is that such understanding empowers citizens of the future to challenge decisions with some confidence by enabling them to ask sensible questions. To be able to engage with science issues in an informed way, there is need to be able to look beyond the claim, and consider data collection and analysis required to support the claim (Gott & Duggan, 2002; Curriculum Blue Print: Republic of Botswana, 1998). Practical work as described above provides excellent practice in hands-on science, encouraging learners to more engagement by designing their own investigation and collecting, analysing and interpreting as well as presenting their claim.

3.3.3 Teaching and Assessment in Practical Work

The assessment of practical work in science education has always been important in supporting education change (Hodson, 1992; Gott & Duggan, 2007). Its incorporation

into broader examination structures through clear guidelines such as having practical work counting toward the final mark is thought to be key (Lewin, 1992). This is so because examinations are believed to have a great influence on practice. Therefore excluding the practical work assessment component can weaken the impact of change. According to Lewin (1993), changing material, the syllabus and methods of teaching do not guarantee any significant change unless the examination system is changed. Examinations severely narrow the curriculum as they tend to emphasise the examinable knowledge at the expense of exploration, understanding, practical skills and motivation (Lewin, 1990; Hodson, 1992). By making practical work internally and externally examinable, it makes it more reputable in the eyes of the learners and teachers. Assessment of laboratory work is often built on written tests which do not usually reflect actual performance in a real situation.

3.4 Teacher Related Research

Teachers are fundamental and crucial to the effectiveness of educational provisions (Loucks-Horsley at al., 1998). An example that shows the recognition of role played by the teachers as well as the impact of situating assistance to teachers, is found in Kelly (1999). He gave an example of a curriculum change involving introduction of mixed-ability grouping in science that worked smoothly and effectively because suitable in-service courses were made available on demand to teachers. These were tailored, not to the ideas of advisory staff of what was needed, but to what the teachers themselves asked for (Kelly, 1999). It is clear that whether it is pre-or in-service, a good professional development program for teachers is essential for successful implementation of any new curriculum. The teachers' importance in the success of curriculum implementation is not always recognised. This is believed to be so because educational research and interventions have always focused on the learner or materials rather than on the teacher (Fullan, 1998). According to Fullan (1998), what teachers need is help and advice starting from the stage of initial training onwards until they can stand on their own. Standing on their own can be evidenced by them becoming reflective practitioners in their subject areas, capable of evaluating their own work with a view to continuous improvement it (Lumpe et al., 1998; Hopkins & MacGilchrist, 1989; Loucks-Horsley et al., 1998).

Bringing the best out of teachers is achieved through school-based teacher development practice. According to Lumpe et al. (1998), individual teachers develop their own knowledge of teaching in the process of reflection in action in their own situations rather than in a centrally organised course. Mass production dissemination processes such as the central-periphery modes of informing teachers have been found to be ineffective (Stenhouse, 1975). Effective implementation of a curriculum occurs when dissemination procedures in association with professional development occurs in the locality of the school, engaging teachers (Hopkins & MacGilchrist, 1998; Kelly, 1999; Loucks-Horsley et al., 1998). In this setting, teachers are responsible for identifying where support needs to be directed.

Teacher knowledge and teacher change issues will now be discussed. These are important due to the teacher's centrality in curriculum implementation and what goes on inside a classroom. First teacher knowledge related information will be discussed. In addition to factors already mentioned which work against effective curriculum implementation, there are various other complexities which equally influence successful curriculum implementation. These include factors related to preconceptions of teachers about teaching, school contexts, as well as teachers' subject matter knowledge (SMK) and pedagogical content knowledge (PCK), which also play crucial roles. Various studies have been done in these areas to show the role SMK and PCK play in the teaching of science and consequently on implementing a new curriculum (Shulman, 1986; Gess-Newsome & Lederman, 1999; Loughran et al., 2006). This should be expected since a new curriculum brings in new features such as new topics and teaching methods (Fullan, 1998).

3.4.1 Subject Matter Knowledge (SMK)

Knowledge of subject matter involves teachers' understanding of the central concepts and structures of the discipline taught with enough flexibility to create learning experiences that make the content meaningful for learners. The teacher's knowledge of subject matter is considered an essential attribute for effective and successful learning. The role of the teacher is to help learners build their own knowledge using material and engagement in meaningful learning experiences. Knowledge of subject matter comes from the teacher's possession of in-depth understanding of major

concepts, assumptions and ways of knowing which are central to the discipline taught. In daily handling of classroom activities, it is important that the teacher evaluate resources and curriculum materials for their comprehensiveness and usefulness for representing certain ideas and concepts. The subject matter knowledge would be essential for the selection and evaluation of teaching materials and resources (Gess-Newsome & Lederman, 1999).

From the above review, it becomes easy to see that teachers' SMK is a critical factor in the implementation of a new curriculum. The same is true with professional development that is also affected by subject matter knowledge of teachers (Loucks-Horsley et al., 1998; Rogan, 2007). Observations show that certain concepts or ideas about teaching can be understood easily by teachers whilst others require more extensive in-service training. Lack of or inadequate SMK could lead to low confidence in teaching. Accordingly, competence in subject matter promotes a disposition towards lifelong learning, has curricular implications and promotes a spirit of inquiry. A sense of community which is built through a shared understanding of the major concepts, assumption and ways of knowing that are central to the discipline being taught are essential. According to Wenger (1998), Loucks-Horsley et al, (1998) and Gess-Newsome and Lederman (1999) teachers with a good depth of SMK have:

- Strong knowledge base which enables them to be empowered in the classroom to focus pedagogical skills and to assist learners in the constructions of their understanding
- The sense of sharing expertise with learners, colleagues and the professional community

While there is no suggestion that teachers have poor content knowledge in Botswana senior secondary schools, as all teachers possess at least a Bachelor's degree in chemistry education, suspicion falls on teachers' SMK and PCK. Lack or inadequate SMK could be expected in the newly introduced topics (Loughran, Mulhall & Berry, 2006).

3.4.2 Pedagogical Content Knowledge (PCK)

Newly introduced topics have been found to present problems even to confident teachers who were unsure of how to transform the new knowledge into understandable format. Knowledge of how to transform content is known PCK (Shulman, 1986; Loughran, et al., 2006).

The idea of PCK came as a result of studies in teacher cognition, in an attempt to elucidate cognitive understanding of the SMK and the relationship between such understanding and the instruction teachers provide for students (Shulman, 1986; Loughran et. al., 2006). Since its emergence, the construct of pedagogical content knowledge has significantly impacted on pre-service and in-service teacher education and educational research. PCK has re-focused educators' attention on the important role played by subject matter in educational practice.

According to Shulman (1986), PCK includes the most useful forms of representation of concepts, the most powerful analogies, illustrations, examples, explanations, and demonstrations. In other words, it is about the ways of representing and formulating the subject that make it comprehensible to others. PCK also includes an understanding of what makes the learning of specific topics easy or difficult, for instance, the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons (Shulman, 1986; Hewson, 1996). Pedagogical content knowledge is an amalgam of common elements such as: knowledge of subject matter, knowledge of students and possible misconceptions, knowledge of curricula, knowledge of general pedagogy.

The concept of PCK is based on the belief that teaching as a profession has a knowledge base for teaching. It is about that blending of content and pedagogy into an understanding of how particular topics, problems or issues are organised, represented and adapted to the diverse interests and abilities of learners and presented for instruction (Shulman, 1987). A teacher can have the correct SMK and not teach a good lesson, or lack SMK though possessing adequate teaching experience. PCK is a type of knowledge that teachers develop through experience about how to teach particular content in a particular way in order to lead to enhanced student

understanding (Loughran et al., 2006). To recognise and value the development of one's own PCK, a teacher needs to have a rich conceptual understanding of the particular subject content they teach. As indicated earlier, content knowledge is not expected to be a big problem to Botswana chemistry teachers since all teachers have the minimum teaching qualifications required. However, Loughran et al. (2006) point out that the rich conceptual understanding combined with expertise in developing, using and adapting teaching procedures, strategies and approaches for use in particular classes might be a problem. This is so because the purposeful creation of this amalgam of knowledge of content and pedagogy described by Shulman (1986, 1987) as PCK is not acquired easily. Many teachers are challenged by constructing their teaching in such a way that ensures that the particular content is understood by students (Prophet & Rowell, 1993).

Loughran et al. (2006) claim that both beginner and experienced teachers teaching a new topic may have little or no PCK on certain areas which may limit students' learning. This is interesting because there are some new topics introduced in the BGCSE curriculum and the teaching force comprises a significant number of young and inexperienced chemistry teachers. Questions have been asked about the possibilities of successful teachers' PCK to enhance novice teachers' PCK.

Representing PCK is based on views that teaching is complex, and also that there are many effective ways of teaching any particular science content (Shulman, 1986; 1987; Loughran et al., 2006; Loughran, Mulhall & Berry, 2004). Hewson, (1996) has pointed out other factors influencing teaching and learning such as alternative conceptions (misconceptions) about science ideas and learning and teaching. The learner can be helped to construct concepts if the teacher diagnoses the existing concepts and sequences learning material so that the child struggles to construct meaning by himself or herself. The fact of going through making meaning is crucial in constructivism because it enables the learner to get into the pitfalls of misconceptions and once the learner rises from these, there is bigger possibility that learning would have occurred permanently.

The importance of teachers' SMK as well as the knowledge about learners' conception, has been highlighted in reviews. This calls for ways of challenging their

conceptions to improve understanding (Hewson et al., 1996; Hewson, 1996). As opposed to transmission of content, it is necessary to create meaningful and engaging activities about science, ideas between students and or teacher and students. It is clear that this perspective about PCK relates to the teacher's knowledge that can help them develop and apply teaching approaches that promote students learning.

Students' preconceptions have been researched and their influence on learning discussed. Readings show that teacher conceptions about teaching which they build up from their own experiences during schooling and training, impact on their practice (Gallagher, 1991; 1996; Hand, 1996; Tobin, 1996). According to them, individual teachers are believed to develop their own pre-conceptions about the nature of what they are going to teach which also determines what to teach and how it is taught. The belief system might have an influence on how the teacher approaches the main learning objectives (Loughran et al, 2006; 2004). Literature on SMK, pedagogical content, alternative or misconceptions shows that it is possible that the pre-conceptions can be at conflict with the views or intentions about teaching as expressed in curriculum documents (Hand, 1996). Such conflicting positions can lead to teachers feeling alienated and consequently unsatisfactory association with the curriculum. Teacher change related information will now be discussed.

3.4.3 Teacher Change

As stated earlier, the teachers' role in curriculum development has been described as crucial to the quality of education or innovation (Kelly, 1999; Hopkins & MacGilchrist, 1989; Lubben et al, 1995). Literature on teacher development, successful curriculum development or education, reported common characteristics that seem to define successful reform strategies.

Other scholars have studied effects of certain variables in introducing change at classroom level (Bowyer, Ponzio & Lundholm, 1987). For instance, teachers were exposed to different conditions such as long or short workshops, some of these given an opportunity to practice the new strategies. Significant growth in terms of ownership or awareness of intentions appeared only when workshops were very long. Hands-on practice did not bring any significant growth, but in-class or school-based

support brought the greatest input. This was also reported by Kelly (1999) on introduction of mixed grouping in secondary schools in England and Wales, which worked well due to the in-service courses offered which had been tailored specifically for their needs. He also reported another implementation of a national project which turned out to be successful. Mixed gains were reported by Rogan (2007) on the Mpumalanga Secondary Science Initiative (MSSI). The core thing from all the reviews was that, teachers who received in-service training on demand achieved more success than those who received general assistance. Strong and effective administrative support is an important factor in influencing such success (Rogan, 2007).

Tailored conceptual change strategies targeting not only preconceptions but also teaching and learning have been effective in pre- and in-service teachers (Duit & Confrey, 1996; Hewson, 1996). According to Hewson (1996), the conceptual change model is a learning model which can be used for the teacher as a learner.

3.4.4 Change in Classroom Practice

In a classroom situation, change usually involves using new approaches to handling familiar content or even handling of new context. Change according to Fullan (1998) is a complex and risky journey, as it involves several components which are difficult to control such as altering teachers' beliefs systems, altering teachers' behaviours and teaching approaches. Any of these can turn out to be the bottle-neck to implementation (Lumpe et al., 1998).

In this study there was a search for what had changed in classrooms since the introduction of the BGCSE curriculum. Fullan (1998) has equated the implementation of a curriculum to a journey. Hence it would be interesting to find out what has been happening in the course of the journey. Views about teachers' perceptions about the BGCSE curriculum, the envisaged changes will be sought so as to shed some light on the teachers' thinking about curriculum, teaching tasks to include learner-centred approaches in teaching, to involve teaching science through its contextualisation and to use problem solving techniques. According to the Curriculum Blue Print (1998), these changes were considered desirable because of the prospect of increasing

students' involvement in hand-on activities. Rational work was also seen as a complementary process in bringing active learning as learners become engaged in the minds-on learning process, rather than passively absorbing from the teachers. Finding out what teachers say and also observing what they do in classes will reveal the change processes and alteration in teacher views.

It had been found that teachers generally still prefer the most efficient and quick ways of delivering concepts. That is, teachers are said to prefer modes that align with traditional pedagogy, where materials to be learned are transmitted to passive students (Garegae, 2003; Tobin, 1996). In studies where teachers are encouraged to employ completely learner-centred approaches to teaching, it was observed that though teachers may use innovative teaching materials and methods as intended, it does not mean that they have changed their ideas about teaching (Pinto, 2005; Garegae, 2003; Kelly, 1999). Changing teaching approaches requires a conviction. Lantz and Kass (1987) conducted a study on science teachers who were asked to use learner-centred chemistry materials called ALCHEM. These teachers were observed to use the curriculum material in various, unexpected ways. Their approaches were found to be in conflict with their own philosophies of teaching and they therefore adopted the materials in various unpredicted way in spite of support, pressure and facilitation. In the study by Lantz and Kass (1987) some teachers used the materials as teacher resources, whilst others continued to use teacher-centred strategies and reporting. The use of materials was found to be influenced or guided by value for what Lantz and Kass (1987) called pedagogical efficiency and academic rigour.

According to Lantz and Kass (1987), pedagogical efficiency is associated with teaching that places value on fast, effective ways of delivering chemistry concepts. The value for efficiency in delivery ahead of quality in delivery, follows from challenges mentioned such as syllabus overload and need to complete the syllabus. Quality of teaching is interpreted and guided by students being able to correctly answer assigned or examination questions.

A second view of teaching emphasises what Lantz and Kass (1987) referred to as academic rigour. Teachers holding this perception supplemented their teaching with detailed background material and challenging problems aimed at developing students'

intellectual abilities. Teachers with academic rigour give a lot of exercises, homework, and problem solving tasks to prepare learners for tests.

The above picture from various studies, illustrates that change in teaching practice is very complex. Each study highlights the centrality of the teacher in these changes whether the change is good or bad. It is evident that there is a difference between acquiring the materials and putting them to use according to the purported way. According to Pinto (2005), change in teaching approach constitutes a constructivist approach to teaching science. It was found that some teachers want to retain their original approaches while at the same time they recognised the need to change.

3.5 Summary of Sections

The theory of curriculum implementation (Rogan and Grayson, 2003) and the situated perspectives formed the major framework for this study. The framework has been discussed at length. This framework offers a means of assessing school situations through the use of the three constructs and identifying those areas that require specific support for teachers and learning in order to be effective. The framework was very relevant as this study aimed to identify factors in school designs and organisation that best promoted new curriculum implementation.

According to literature discussed above, there are many disadvantaged schools in South Africa in terms of capacity factors. This was established through the use of Rogan and Grayson's framework (2003). Not much is known about the school situations in Botswana and especially how the physical resources, teacher, and other factors impact the implementation of the new chemistry curriculum. The framework discussed has the potential to identify gaps or areas that little are known about, for instance, levels of operation associated with different schools and factors operating. In this study, the ZFI concept was also investigated to determine its usability.

Following the above review, it was important to look at the literature relating to the methodologies guiding the study.

CHAPTER 4 METHODOLOGY

This chapter contains a description of the research design, the nature of the population, as well as data collection and analysis approaches. The research study was qualitative in nature, conducted within the framework of a case study. A case study approach was chosen for this study because of its versatility and especially its link with qualitative researches. This chapter will cover the following sub-topics:

- What the case is and how it was identified in this study
- The type of case study approach adopted in this study
- The nature of validation, ethical considerations in this study and case study designs
- Development of instruments and the sample
- Data collection procedures and analysis

It is important to give a background to case study in general so as to illuminate how it differs from other forms of naturalistic study approaches. What distinguishes a case study from other naturalistic approaches is principally the subject which is to be explored as the methodological orientations are similar (Bassey, 1999; Denzin & Lincoln, 2000; Hitchcock and Hughes, 1994).

4.1 Case Studies in Science Education

4.1.1 Background to Case Studies

Inquiries into science education done using naturalistic methodologies are very common. Here individual constructions are elicited by interactive dialogue between the researcher and the participants (Hitchcock & Hughes, 1995). According to Bassey (1999), one of the characteristics of a case study is that it concentrates on a particular incident and attempts to locate the story of a certain aspect of behaviour in a particular setting and the factors influencing the situation. These points towards a case study having characteristics such as having

- A concern with the rich and vivid description of events within the case
- An internal debate between description of events and analysing events
- A focus upon particular individual actors (such as teachers, departments and classrooms) or group of actors and their perceptions

- A focus upon particular events (such as teaching, relationships) within the case

In this study, employing a case study included looking in-depth at:

- How teachers are implementing the BGCSE curriculum
- The kinds of teaching and learning occurring in the selected schools
- How science teaching, especially the BGCSE chemistry was conceptualised by teachers and students in classrooms and
- How other external factors such as departments' ecologies and resources influenced the curriculum implementation and teaching situations

When to Use a Case Study

Reviews show that in general, case studies are preferred strategies when the 'how' and 'why' questions are being posed (Bassey, 1999; Yin, 1994). This seemed relevant looking at the aim of the research study as stated above. The method is also suitable as in this situation, when the researcher has little control over events and when the focus is on a phenomenon within some real life context.

Different applications of case studies have been identified, one of the most important being to explain the casual links in real life interventions such as how contexts are impacting on teaching and learning in classrooms (Bassey, 1999). This makes it possible to link implementation contexts with the effects it produces. Another use of the case study is to describe an intervention or implementation and the real life context in which it occurred. Case studies are also relevant in those situations in which the intervention being evaluated has no clear, single set of outcomes. In such a situation, the researcher has a big role in defining the evaluation questions and in getting the relevant data categories (Stake, 1978). Taking all these into consideration seems to be suitable for the study described in this thesis as it intends to explore and explain what is happening following the implementation of BGCSE curriculum in Botswana secondary schools.

Long History in Social Sciences

The case study approach has a long history in the social sciences (Hitchcock & Hughes, 1995). Case studies have also been used extensively in science education, for

instance, a study by Stake (1978) to report on the status of pre-college science education in the United States of America in 1976. This study could be regarded as similar to the study undertaken here. In the study by Stake (1978) issues and existing practices and outcomes were identified, explored and described by the researchers with the intent of providing a link between the curriculum developers and the practitioners. Clearly, community studies and small scale studies of organisations such as schools are all regarded as belonging to the general category of a case study (Denzin & Lincoln, 2000). Advocates for the approach argue that it is capable of exploring a situation in depth as it has to be done over time (Bassey, 1999). Being conducted in clearly bounded environments makes it more focused and intensive.

The use of case studies is connected to its ability to offer an opportunity for the collection of detailed, relatively unstructured information from a range of sources such as concerning teachers, learners and schools. It offers opportunities to take account of life experiences of teachers and students while focusing upon schools and classroom processes (Bassey, 1999; Hitchcock & Hughes, 1995). The method's suitability also lies in the fact that much of educational research deals with people and not static objects (Yin, 1994). It thus allows people to tell stories about their situations to others to make sense of the worlds they inhabit (Stake, 1978).

The design of the case study used will now be discussed.

4.1.2 Identifying the Boundaries

Case studies were undertaken to provide a rigorous view of chemistry education in a small number of senior secondary schools in Botswana. According to Denzin and Lincoln (2000), a case may be simple and straight forward or they may be complex and extended, but its centrality lies in the focus and emphasis upon the clearly bounded and unique nature of a setting which has some kind of internal coherence. The core for its identity lays in its conception of unity or totality that bounds the system like a school and it is a part of this unity that is studied. According to Stake (1978),

> … the case is made the focus of attention rather than the population. In most other studies, researchers search for an understanding that ignores the uniqueness of individual cases and generalises beyond particular instances. They search for

> what is common, pervasive and dependable. In the case study, there may be or may not be an ultimate interest in the generalizable…the search is for understanding of the particular case… in its complexity…. (Pg C30)

It is clear here that the interest is on the activities of the case and not on generalising the results across schools in the country. Since the study intended to look at teaching of the BGCSE following its introduction in 1998, a case study is handy in that it gives opportunity to look at the common, widespread and general (Stake, 1978), but it also allows for attempts to identify anything unique or particular to a school setting or individual teachers. It is not a problem accomplishing these in case studies as it allows for employing of a variety of data from a variety of sources (Denzin & Lincoln, 2000; Bassey, 1999).

As stated above, in a case, it is important to identify the boundaries, decide what is in fact inside the case to help concentrate the research strategies appropriately. I have decided to use a diagram to help in breaking a case down into its key players, key situations and critical incidents like the school, the science department, the facilities, the science (especially chemistry) teachers, and the implementation of the BGCSE (chemistry) curriculum and how they link with each other.

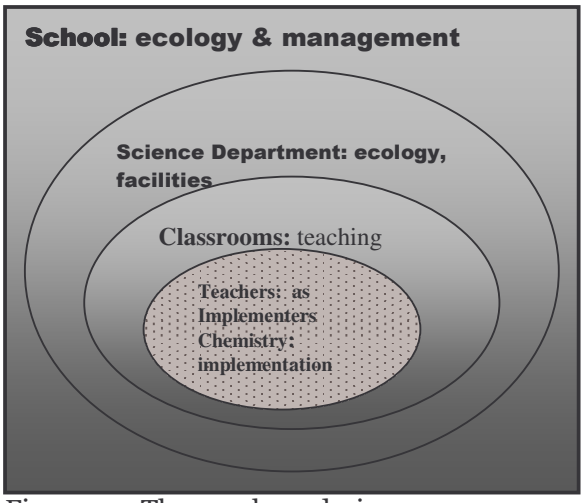


Figure 4.1: The case boundaries

Breaking the case into key player helped focus the research aims so as to help locate key informants and establish teachers' new identities (Brown & Schulze, 2002).

In such a case study of the new BGCSE curriculum which hoped to bring new teaching strategies in the senior secondary schools in Botswana, the scope and boundary were identified as shown in figure 4.1 above. This included looking at the school setting drawn from factors related to the Rogan and Grayson (2003) constructs such as chemistry facilities, chemistry teachers, the science department in general, school ecology and management, through the eyes of the teachers.

Identification of the case meant locating the boundaries, identifying the key players and key situations which might have impact on the chemistry teachers and the implementation. Miles and Huberman (1994) argue that exactly defining the scope of the case, that is where the case ends and should begin is not easy, hence guidelines from Rogan and Grayson's (2003) theory of implementation were helpful in this regard in mapping up things to look for. Miles and Huberman (1994) argued that in a case study, there is a focus, a heart of a case and a boundary, but the boundary does not have to be studied. In this study all the three are looked at but at different degrees.

In this research study the formulation of the case could be said to be defined in terms of the following;

- Having boundaries set by an individual school which allow for its own definition
- Defined by characteristics of the group of teachers teaching chemistry, socialising in the department
- Defined by the role of function of the group as they teach chemistry as well as how they shaped new policy on education to implement the new teaching approaches

Having identified the boundaries of the study, it is equally important to outline the unit of analysis in this study.

The Unit of Analysis

The cases in this study are the four selected senior secondary schools in Botswana. The unit of investigation for each school was three chemistry teachers in each of the four selected schools in the Republic of Botswana teaching chemistry. Altogether there were 11 teachers involved. The unit cases resemble multiple experiments and

the possibility of replication (Yin, 1994). If similar results are obtained from the individual cases, replication is said to have taken place. The study focused on the chemistry departments to chronicle in-depth innovative processes by chemistry teachers. These helped develop a deeper and better understanding of how much implementation of the purported ideas are being followed by chemistry teachers. It was hoped that the cases would make it possible to capture the broad ideas embedded in case learning. In addition, it was hoped to enumerate dimensions in case schools such as preparation for teaching, instruction, and available resources. This also applies to what is driving the teachers' current practice in their classrooms and departments.

Because of the position teachers occupy in schools, each case was organized around chemistry teachers. In this way the case can ascertain the typicality of the situations observed, the accuracy of representations made, the importance of issues raised as well as make suggestions for remedy of the problems faced in schools. Teachers were to provide detailed descriptions and analysis of processes and patterns of teaching relating to their school. They were to illuminate attitudes towards the implementation of the new curriculum as well as their understanding of the demands of the BGCSE.

As indicated in some reviews (Hitchcock & Hughes, 1994; Denzin & Lincoln, 2000), a case can be considered as either the examination of a single instance in action or as the study of particular incidents or events over time. In this study, the case study involved studying and portraying the impact in the schools of the BGCSE curriculum, a new innovation through exploring the experiences of teachers. This also included investigating the influence of the social and professional networks within the schools and especially science departments which seemed to have influence on the implementation processes, as well as the portraying day-to-day life of teachers. A case study is able to get to this because the methods allows the researcher to get close to the teachers, thus giving opportunities to access subjective factors such as thoughts, feelings and desires of teachers.

4.1.3 Different Types of Case Study

There are different classifications of case study approaches. Yin (1994) identifies three types of case studies which seem to all form important components of this study.

He differentiated them in terms of end product as exploratory, descriptive and explanatory. According to these identifications, exploratory case studies have been used as pilots, mainly to generate further research questions or try out data collection methods (Yin, 1994). Descriptive case studies are aimed at giving a narrative account of social situation. The approach is able to generate a lot of detail but low in theory building opportunities making it less suitable for some research studies. The explanatory case study, which tends to be used either to generate a new theory or test an existing one, seemed relevant too. But all these classifications highlight overlapping occurring and the implications being that drawing from more than one model is an advantage.

A case study can follow a persistent study of a single case or be a multiple case study project, which is a collection of individual case studies (Yin, 1994; Stake, 1978). In the study described in this thesis, multiple case studies have been considered a more relevant methodology than single case studies. Considering the diversity of school situations due to their locations and length of operation, multiple case designs have distinct advantages suitable for such situations. This is so because it allows for investigations of what is particular to individual persons, to individual classrooms or individual schools. Differing views are permitted as they lead to multiple realities that become visible in each of the case studies. In this study, issues and existing practices and outcomes were identified, explored and described by the researcher with the intent of providing a link between the curriculum developers and the practitioners.

The evidence from multiple cases is often considered more compelling and robust (Yin, 1994) than from single cases. According to him, whenever single cases are involved there is always a potential vulnerability in the design that the case may later turn out not to be what it was envisaged at the outset. Where the same study consists of multiple research areas, this is where the multiple case designs are more appropriate. The research described here tracked cross-national implementation of a chemistry curriculum by all schools in the country under various conditions, situated in different backgrounds such as rural areas, semi-urban to urban areas. Each school therefore presents its own case (Stake, 1978). In this study, none of the single case criteria seems important enough to warrant it being looked at independently for a critical instance, an extreme, unique case or revelatory case. Instead it made sense to

have various schools so that each case gives its own story. Certainly using this approach seems best as the researcher can draw on more than one case. Though there is diversity highlighted by the different cases, there are a number of aspects which are shared to help draw common and general aspects of the cases.

4.1.4 Case Study Overview

Four schools were engaged in the study. Each was carefully selected so that it predicts similar results often called a literal replication or produces contrasting results but for predictable reasons (Yin, 1994). I wanted to select a manageable group of cases that would illustrate the diversity of the total number of schools and yet show the need to examine the complex nature of chemistry education in each. This therefore does not assume a replication logic and is different from sampling commonly used for instance in survey. In sampling logic, the four schools would be assumed to represent a larger pool of the schools or the teachers in the country. The data and reports from a smaller number of schools are assumed to represent the data that might have been called from the culture pool. Multiple case studies demand a form of linkages, a manner in which to discuss their differences and similarities (see figure 4.2).

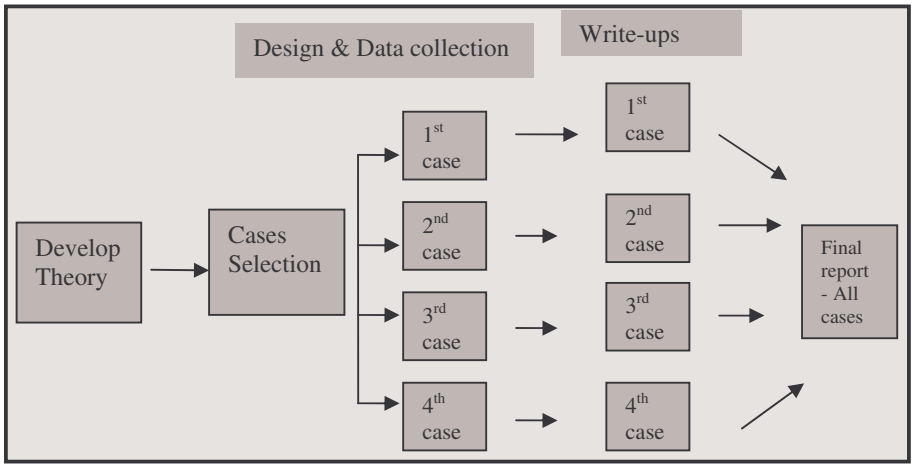


Figure 4.2: The replication figure illustrates the overview of this study

In this study, the design above is appropriate because of the study of an innovative curriculum (BGCSE) in which independent implementations occurs at different schools under different contexts through different teachers. Hence each school is used as a subject of an individual case study (Rogan & Grayson, 2003). Every school as a case serves a specific purpose with the overall scope of inquiring about the teachers,

students, a class, and instructional methods. Evidence from the multiple sources was eventually used to converge as a common set of findings.

Such case study reports are significant because the illumination of patterns and their driving forces could be useful in other schools. Though not generalisable, by making a case available to teachers or readers, it can help the readers to see their experiences in new light. In the same way experience with a variety of situations helps one to understand events in different ways, such cases can expand the range of interpretations available about the schools in the country. As Pinto (2004) puts it,

> The corresponding advantage of cross-national research was that features of the local context, often rather invisible to the local eye, which takes them for granted, were thrown into relief when context was understood from a different national perspective (pg 6).

The design is appropriate to accomplish the above since findings are communicated in non-technical language that is accessible to all consumer readers in the country.

4.2 Case Study Designs

Whilst this study was primarily committed to studying chemistry teaching and the teachers, the study was also committed to studying school contexts. These were basically the circumstances under which chemistry education occurred. Data collection for these case studies relied on mainly four important sources. These were documentation, interviews, observations and physical artefacts. It can be argued that there is merit in moving beyond simply choosing between methods. Combining a number of methods is valuable because it improves the construct, internal and external validity of the research as it provides a mutual confirmation of the research problem through triangulation (Aldridge, Fraser & Huang, 1999; Yin, 1994). Triangulation is important since there is no method that can capture all the changing features of a social world of study like a school or classroom (Aldridge et al., 1999; Yin, 1994; Fraser and Tobin, 1991).

4.2.1 Data Collection

Participant observation and open-ended interviews formed the main data sources. These techniques are usually associated with the theoretical approaches of qualitative

research (Schumacher & McMillan, 1993), concerned with ways in which people interpret experiences and make sense of their world. The methods were suited for this study as there was a need to interact with the school environment, the teachers and learners in their environment. On the other hand, it should be expected that the method is somewhat personal in that no researcher observes, interviews or studies documents exactly like another (Stake, 1978). But the agreement on the description and composition of events especially the meanings between the researcher and participants were enhanced through observer reliability, (see table 4.1). Threats to reliability were reduced by the use of a combination of verbatim accounts, mechanical recorded data, member checking and participant review (Hitchcock & Hughes, 1995; Yin, 1994; McMillan & Schumacher, 2006). Putting these together reduced threats to reliability by allowing corroboration of findings.

I spent three weeks in the field for each case. This helped minimise many sources of invalidity by providing opportunities for continual data collection, analysis, comparison and corroboration to refine ideas. This also gave me the opportunity to conduct a number of interviews and obtain documents about the school from various sources (see table 4.2). Participant reaction, independent corroboration and confirmation were done at all stages of the research process to help identify sources likely to produce contrived or biased information.

4.2.2 Ethical Considerations

In involving qualitative studies there is a moral obligation that the purposes for the study be made clear to all participants (Zevenbergen, 1998). The step was taken in all the schools involved, outlining the intentions of the study including the nature of data I was looking for. This was crucial because different types of data were eventually obtained to them. For instance, in this study very sensitive information was gathered from teachers concerning the school's ecology and management system. Assurances to protect teachers' identities, schools identities in this study helped teacher to participate without fear of victimisation. This also helped schools to participate and teachers to talk without fear of exposure. Assurance to keep schools and all involved subjects unidentified was enough to consolidate trust, hence the teachers' high level

of participation and openness during interviews and lesson observations was witnessed. Evidence of this can be seen in Appendix K, a teachers' transcript.

The difficulty in this study was in reporting in a way that would totally conceal identity of teachers and schools in the country of Botswana. This was so because of the nature of the data used in the report which included photographs about the school, science departments, teachers and students (in uniforms) which could lead to revealing identities of the schools and eventually the teachers. This problem was compounded by the fact that as indicated earlier, Botswana is a sparsely populated and with very few senior secondary schools (27). Nevertheless, necessary steps were taken to ensure that maximum protection of the subjects was achieved such as careful selection of photographs.

Literature shows that using pseudonyms can be a very good way of protecting names. Since only four schools were used, the researcher ensured that the names of the districts, villages and towns from which the schools were located were not revealed. The fact that schools in the Botswana more or less possess the same kind of infrastructure makes it difficult to tell some schools apart just by looking at the resources. For instance, looking at map of Botswana (figure 4.3) identifying the locations of the schools by numbers 1 to 4, Tagala SSS could be in any of the regions. There are a number of senior secondary schools in some relatively small villages in all the regions given. The same could be said about Lesedi SSS which is situated in a large village. All the marked regions have large villages, all with a senior secondary school. Since none of the school was identified as situated in a particular region it is not possible to assign any school to any region. The regions marked do not tie up to the districts, but were merely done to show the spread of the school along most populated south to north-eastern belt. More than 20 of the 27 government senior schools are located there.

4.2.3 Validating Case Studies

There is a need to have appropriate terms and concepts to be carefully thought out that are consistent with one's paradigm (Hitchcock & Hughes, 1995; Miles & Huberman, 1994; Denzin & Lincoln, 2000). These authors in line with case study paradigms have

thought out concepts and various strategies to deal with issues of validity and reliability in qualitative researches. Below is a list summarising some of the recommended terms proposed when dealing with qualitative inquiries (Denzin & Lincoln, 2000; Miles & Huberman, 1994).

Table 4.1: Recommended terms to deal with validity in qualitative inquiries

Terms	Scientific Inquiries	Naturalistic Inquiries
• Truth value	• Internal validity	• Credibility
• Applicability	• External validity	• Transferability
• Consistency	• Reliable	• Dependability
• Neutrality	• Objectivity	• Confirmability

There were various steps taken throughout the course of the research study concerning the issues of validity, reliability and generalisation. All the above naturalistic inquiry terms will be described and linked to the steps that needed to be taken to ensure that they are met in this study. The steps include the phases at which they were applied.

The need to ensure the credibility of results meant that I had to remain conscious and take care of my position about being 'objective' and 'subjective'. The step was important as it concerns the extent to which other researchers can use the findings of this study. Another issue of concern was validity and reliability. Validity has to do with the degree of capturing the reality of the situation under investigation (Denzin & Lincoln, 2000). Another term linked with issues of validating case studies is transferability. Transferability intends to establish the extent to which findings from the study can be used by another researcher. This is about how readers demonstrate applicability of the set of findings to another context. The other important issue of validating the data in naturalistic studies concerns the issue of whether the process of the study is consistent with time and across other researchers. Finally confirmability concerns issues of whether other researchers can repeat the study and arrive at the same findings. This involves ensuring that the findings of the research are grounded in the data rather than in the whims of the researcher. Accordingly, if the findings are confirmable, an external observer should be able to reconstruct them by way of the data. To allow this to happen, Lincoln and Guba (1985) suggested that the researcher provide an audit trail. Such an audit also can be used to ensure dependability of the data.

Table 4.2: Steps needed to ensure validation of data

Tests	Case Study Tactic	Phase of Research
Construct validity	Use multiple sources of evidence Establish chain of evidence	Data collection Data collection
Internal Validity	Do pattern matching Do explanation building	Data analysis Data analysis
External Validity	Use replication: Multi-case study	Research design
Reliability	Use study protocol Develop case study data base	Data collection Data collection

Generally, all these validation processes formed part of this research study and were taken into consideration at various stages of the research study. Various criteria were developed to determine and ensure validity and reliability is met. Some of these issues are discussed further under different or relevant topic concerning data collection and analysis processes. Generally, the brief statements below summarises some of the criteria followed to ensure validity and reliability such as:

- Comparison of interviews on BGCSE with data collected from classroom observations. This step ensured whether there were differences of opinion or agreements on curriculum related issues, implementations and practice, and to help provide explanation for any differences that may have occurred.
- The data from various sources (interviews and classroom observations) were regularly contrasted to either corroborate or dispute the findings
- Purposive sampling of regions, chemistry teachers, and an interview guide ensured questions related to teachers' experiences helping with the issues of reliability and validity of findings.
- Objectivity of findings was ensured by providing a detailed description of how the data was collected, processed and displayed to assist with drawing conclusions
- Personal bias was solved through preparations made through piloting and having teachers corroborating their views
- A variety of methods, multiple data sources (teachers, different classes, schools) triangulation of various types
- Prolonged stay and involvement with the schools, science department and classroom observations on various sites helped

Although independence of each site was pursued, generalisability was to some extent the goal. This was not because of an interest in some particular place or some particular idea, but because of the need to make these studies useful to teachers. This

helped guide the search for generalisability based on deep understanding of phenomena, which increases one's opportunity to recognise similarities. Each case was designed to depend on this kind of generality.

4.3 Development of Instruments

In order to gain insights into capacity and practice in schools, the interviews, observations, and resources checklists were developed, based on the BGCSE intentions and school contexts. The characteristics of instruments and their dimensions were linked to the research questions and the data to be obtained. The following are some of the broad issues the instruments were based on or hoped to illuminate:

- State of school and science department (especially chemistry section)
- Classrooms (and other physical structures)
- Chemistry laboratory: which included the plan, setting, conditions, facilities and equipment and their conditions, adequacy and use
- Teacher-pupil ratio, qualifications, turn-over, socialisation
- Science department's philosophies etc

A summary below shows the guide according to some of the research questions.

Table 4.3: The research design

Research question	**Data sources**	**Data collected / dimensions**
1. How was the BGCSE chemistry curriculum perceived by the chemistry teachers?	Teacher interviews / talks	Teacher attitudes and perceptions Curriculum changes, assessment & teaching practices
2. How was the teaching and learning of chemistry conceptualised by the teachers?	Teacher interviews; Classroom observations	**Classroom interactions** Presentation of content; Learner engagement: question type/level; Structure of learning activities; Facilitation of learning **Science practical work** Demonstration: develop concept, promote inquiry; Nature of practical work (closed, guided discovery type, in groups, hands-on); Nature of communication of data Open investigation (design and do) **Science and society** Class examples- Everyday life, application
3. How did designs and organisations in schools promote or inhibit new curriculum implementation in Botswana secondary schools?	Teacher interviews; Observations; Resource check list; School check list	Science departments/chemistry laboratory- which included the plan, setting, conditions, facilities and equipment and their conditions, adequacy and use Driving-force persons; Changing roles of teachers and; Changes in science that may affect science curricular; Diminishing budgets for education; Adversary roles of teachers and administrators

Capacity Instruments

The questions on capacity set out to find schools' capacity to innovate through the dimensions *physical resources*, *teacher factors*, *learner factors* and *school ethos and management*. The observations and interviews were structured under the above dimensions with their distinguishing characteristics. They were used at various times of the study to establish capacity of schools (refer later in chapter).

Practice Instruments

To find the schools' level of practice, observations and interviews were used based on some of the dimensions found in the profile of curriculum implementation. The observation schedules and interviews were based on some of the dimensions about practice indicated in table 4.3 above. The above information helped direct and shape the observation instruments, interview questions and observations made in the schools. Soon after preparing the observation and interview schedule, it was necessary to evaluate the functionality of the instruments.

Preparations for Piloting

In qualitative research, the researcher himself or herself is the instrument of data collection (Lincoln & Guba, 1985; Stake, 1978). The researcher went to the field as a sensitive instrument to gather information on chemistry education in the context in which it is taught and learned. In this research study, I gathered data from a wide range of sources such as interviews, direct observations and from a laboratory checklist and school observation schedule.

Prior to the actual data collection exercise, preparation for doing this case study included prior training and skill development of the researcher. To this end, I organised preparatory sessions in the form of seminars to help develop necessary skills. I pre-piloted the protocols by observing peers teaching in one secondary school in Johannesburg where observation and recording skills were learnt and practiced. This was a very crucial phase in this research as a multiple case design demands an examination of the researcher's intellect, ego and emotions as they can easily make an impact during data collection. The piloting had the necessary result in that I became acquainted with the typical surroundings so that it was possible to take on any unexpected opportunities rather than being trapped by them. This also helped guard

against potential bias. Ultimately, I piloted study in September 2004 for one week. The skills I learned were to:

- be a good listener; have a firm grip of the issues involved; ask good questions; be adaptive and flexible; be unbiased by my preconceived notions

The Piloting

The pilot study was conducted in Kakale SSS in Botswana in September 2004. It involved working with four chemistry teachers. All data collection strategies and instruments were trialled during the space of one week.

The study employed qualitative research methodology for it to enable the researcher to identify the understandings held by teachers and the meanings they make of their experiences about their school. The research methodology included classroom observations and semi-structured interviews. The initial stage of data analysis involved transcription of all the audiotapes from the teacher interviews and sorting out the observation notes according to the teacher. The piloting had many logistical implications for the main study. For example as a result of my experiences during the pilot week, the duration of the study was increased so as to improve the data collection processes. The number of teachers observed was reduced from four to three per school. This was to help bring depth of data for each teacher. It was during the piloting phase that contacts were established with potential participating schools.

4.4 The Sample and Description of Instruments

The purposeful sampling strategy suggested by Denzin and Lincoln (2000) was employed in this study. It was employed because of the kind of data that was to be collected, the data collection instruments used and also due to the data sources which did not lend themselves to random sampling (Denzin & Lincoln, 2000).

4.4.1 School Descriptions

The sample was drawn purposely from the population of 27 government and government-aided senior secondary schools in Botswana. Access into schools was an important consideration in sample selection. Maximum variation of the sample was attempted in which the selection represented schools from all government and government-aided schools. This was accomplished through targeting schools from

varied geographic locations (towns, larger villages and rural areas), built at different phases (built prior to or after the mid 80s) and covering the densely populated southern, central and the north- eastern parts of the country (figure 4.3). I completed the selection of the schools in the country with the conviction that I had gained access to a suitably balanced sample, free as one could expect a relatively small sample of 4 schools to be of misrepresentative characteristics. A sample of four schools was actually highly representative considering that this was about 15% of all the senior secondary schools in the country. The location of the four participating schools is shown below. The schools involved have been named Domboshaba, Tagala, Maru, and Lesedi senior secondary schools. All government senior secondary schools run a 2 year senior secondary school phase.

Figure 4.3: Overview of the geographic location of the participating schools

While showing the regional locations of the sites for case studies, the exact locations have been disguised to maintain anonymity. It is important to note that, though the locations are not spread throughout the country, the south-eastern belt is the most populated part of the country, which accounts for the sample density. Proportionate populations in the selected schools were the same (table 4.4). The four sites studied were generally representative of the school systems found in the country in terms of size of school system, population characteristics and funding sources. The schools had

more or less the same number of chemistry teachers and all schools accommodated only form 4 and 5 classes.

4.4.2 Gaining Access

Identification of the schools was made easy by the fact that I am familiar with most of the schools, the science teachers and their heads of science departments. After locating the schools, it was necessary to talk to the school authorities. The principals and heads of science department were consulted to establish if the schools would be willing to participate. Schools generally indicated that they would participate as long as there was permission from the MoE and the teachers agreed to participate. With tentative permission from the school authorities, it was now necessary to consult with the MoE, to look for permission to enhance recruitment of teachers. Permission was granted at the beginning of the year 2005. Armed with the letter from the Ministry of Education, schools were welcoming, even where I did not make any prior contact.

The recruitment of teachers took place soon after the permission was given. All teachers in the chemistry sub-department were approached. I was assisted by heads of department, science senior teachers or chemistry coordinators. Selection of teachers did not constitute a random sample as some indicated their interest in being part of the study. Three chemistry teachers per department of about six to seven teachers were used. The total number of teachers who participated in this study was eleven.

4.5 Data Collection Procedures

Data collection took place in the first term of 2005, from three weeks after the term had started to the last day of term. In a way this gave some insight into ecology and activities at the beginning of a term and also as the term ended.

The four schools occupy different positions between low to above average in national league tables of the BGCSE examinations results. Therefore the sample is sufficient to indicate the kind of impact that almost a decade of compulsory implementation of the BGCSE has had on teachers practice and thinking about purported curriculum changes. Three chemistry teachers in each school agreed to take part in the study. The ratio of male to female was 72% to 28%, and all the teachers had less than 10 years

teaching experience. It is important to note that the volunteers were generally less experienced.

I spent 3 weeks in each school observing classroom activities for the selected chemistry teachers. During the 3 weeks, information gathered came from the documentation of the schools activities, as well as from teacher-talk about the instructional strategies they employ in their teaching, and typical problems to teaching the curriculum as they were required to. It was easy to interact with all teachers due my familiarity with the schools and most teachers prior to the study. The table below summarises the four schools observed.

Table 4.4: The four secondary school related information

Name: SSS	**Location**	**Boarding / Non boarding**	**School (old/new)**	**Student population**	**Number of chemistry teachers**
Dombo-shaba	Town / government	*Non boarding*	new	900	5
Tagala	Rural / Government aided	*Boarding*	old	1400	6
Maru	Rural / Government	*Boarding*	old	1400	6
Lesedi	Semi-urban / Government	*Non boarding*	old	1400	5

It is important to note that the data collection took place without any intervention, and so teachers were to do things their normal way. That is, teachers had to do things the way they would have done without an outsider in the school or in their classrooms. The data consisted of field notes, interviews from teachers, students and post lesson talks (reflections about the lessons observed).

The total number of observations per teacher depended on the classes chosen for observation. Generally, a form 4 and a form 5 class were randomly selected from each teacher, but I also wanted to have a mix of different science streams for each teacher. There was a general view that teachers handle the form 4 and 5 and especially the different streams differently. A single observation mainly constituted two consecutive teaching periods, lasting 80 minutes. It could also be a lesson lasting 40 minutes. There were generally few such lessons in science. More observations were made for chemistry triple classes as the classes have more contact time per week (five to six),

followed by the double stream (three to four) and the single streams with two depending on the school. About 30 lessons were observed in each of the four schools.

4.5.1 Direct Observations

Because interactive school scenes are too complex and too subtle to observe or record everything, I did not seek to capture everything that happened. I relied on prolonged field visits and the skills I had developed to decide what should de included or excluded. Observation as a technique relies on the things I saw and heard, and recording these observations rather than relying on subjects' self report responses to questions only. This allows for triangulation. Observations in this research study mainly focused on classroom instruction and learning activities. I also focused on taking notes of the behaviour and utterances of teachers outside the classroom situation. I collected data about the condition of buildings and workplace of teachers, which in a way says a lot about the climate and impoverishment of the school (Rogan & Aldous, 2005). This was made possible by spending a lot of time in the chemistry classrooms and staffrooms where I attended meetings or weekly briefings with teachers. Weekly briefings revealed the issues or nature of debates, contributions, and interactions between teachers across departments or science sections were noted.

Field notes on students included how they learned, their involvement, how they responded to their teachers and peers, and the prevalence of those issues that are supposed to dominate or form part of learning such as activity-based learning, contextualised learning, and application of science (Mortimer & Scott, 2003). On the instructional strategies I noted the extent to which the teachers were prepared for the lesson, the subject matter delivery activities, how they responded to the learners' needs and their questioning styles. That is these ideas purported by BGCSE philosophy or the kinds of challenges they encounter as they implement chemistry innovations. The pertinent issues emanating from the detailed notes written during lesson observations were used in subsequent interviews (especially the informal post-lesson talks or conversations) with teachers, learners and head of departments. This was to help develop a deeper understanding of the didactical culture of the school being scrutinised. Another major data collection strategy used was interviews.

4.5.2 Interviews

In designing the interview schedule (Appendix J), the interest was to solicit information about a teacher's perception of the school experiences, while allowing flexibility. The focus was on teacher processes and attitudes to the BGCSE implementation, their understanding of the theoretical/policy base, and to reveal what they were currently doing in their schools. So a structured set of open-interview questions were devised with this in mind. An open-interview schedule was specifically used as it is more flexible and sensitive to issues that the respondent feels are important. This way, the teachers as main interviewees were able to provide access to feelings and intensions and information that could be accessed through observations, checklists, or document analysis. The interviews with the teachers lasted up to one hour. However, the time spent mainly depended on time constraints and the amount of detail given in the responses.

The interview schedule contained two major sections. The first questions gave contextual information and helped establish rapport, but further questions gave rich information about the implementation of the BGCSE and contextual information about the school. The structured and open-ended framework ensured consistency and allowed the teachers to talk freely about their own experiences. It also gave the interviewer an opportunity to probe further if necessary (Cohen & Manion, 1998, Chisaka, 2002; Yin, 1994). To avoid a situation where the researcher would end up imposing views of the cultural situation, the researcher talked less so that the respondents talked more. All the interviews were audio taped with consent from the subjects and later transcribed. In addition to recording the interviews, I wrote some notes on data collected. This was so because the use of a tape recorder does not eliminate the need for taking notes (McMillan & Schumacher, 2006), as it helps reformulate questions. This also helped to record nonverbal communication, which also facilitates data analysis (Yin, 1994). Tape recording was done to ensure completeness of the verbal interactions. At a later stage this also provides material for reliability checks.

All questions were in English, and all respondents were expected to answer back in English. Some teachers chose to communicate mixing English and Setswana. I made

the translation during transcription to enhance analysis. It is important to note that I am a fluent Setswana speaker. At the end of the data collection, over fifteen individual teachers had been interviewed. Interviews were transcribed and each teacher given a copy of his or her transcript. Teachers were asked to read their transcripts and contact the researcher should they wish to amend or clarify the meanings of their verbal comments (Gustafson, Guilbert & Macdonald, 2002). Rereading by teachers was also another way of checking translation made. Other methods included observation, which formed an important part of data collection.

4.5.3 Laboratory and School Observation Schedules

The researcher developed both the laboratory and school observation schedules used in this study (Appendix H and I respectively). The first step in developing the observation schedule was to define in precise terms what was to be observed. This mainly began with the research problem or questions and the variables that needed to be observed. These were based on the dimensions within the "*construct capacity to support innovation*" discussed earlier (Rogan & Grayson, 2003). The school observation instrument was to gather information on capacity of the schools, mainly looking the physical resources for instance conditions of work place and buildings and the daily routines like attendance at classes, sports, assembly, including teacher and students actions during and after teaching times. The laboratory schedule was to gather an inventory of the materials within the chemistry laboratories (Appendix H). This was important as it formed crucial indicators of the quality of conditions at the school as they impacted on teaching and learning chemistry. Another mode was document collection and analysis.

4.5.4 Document Study

The rationale for using documents in this study was the fact that observations and interviews might not provide a complete picture of the culture under investigation (Chisaka, 2002; Yin, 1994). It was important to have documents as interpretation of these can provide information about the past and clarify the collective educational meanings that may be underlying current practices and issues. In this study the following documents were collected from the schools or chemistry departments

- Government policy document on education

- BGCSE- Chemistry syllabus
- Records of previous national examination results (BGCSE)
- Official documents such as internal memos, government memos, minutes, school brochures, term plan

These documents were important to have since they provided an internal perspective of the schools. Studying these documents gave a description of functions and values and how various people defined the school. To a large extent they also revealed the official chain of command, thus providing clues about the leadership-style and values. The technique of internal and external criticism was applied to all sources of documents (McMillan & Schumacher, 2006). These helped protect the authenticity and credibility of the facts stated in the documents.

4.5.5 Photographs

Photographs were used in reporting the findings of this study. Photographs were taken of the school surroundings, department, during classroom observations throughout the course of the field work. Photographs have been used extensively in qualitative researches to exemplify the classroom observations and interview (Hitchcock & Hughes, 1995). In this study photographs were used mainly to provide a general sense of a setting in conjunction with observations and interviews. They also were used to help support the settings of how teachers and pupils' work places is related to the learning of science or just to show the context of different schools.

After all data had been collected for each case, it was necessary to arrange the data properly for analysis.

4.6 Data Analysis

The first parts of this chapter focused on the research design. The methodologies followed in the study followed were explained and justified. The other part of chapter 4 describes the analysis, reduction and interpretation of the data. First I conducted interpretative analysis of the data by reading the transcripts and field notes. All the data was then subjected to the use of the ATLAS.ti programme to help coding. This was followed by categorising data into more manageable themes, identifying and

isolating what appeared to be important. These themes were used to frame assertions, which were subsequently evaluated in the light of supportive evidence.

4.6.1 Procedures Employed in Reducing and Analysing Data

The initial process of data analysis in this study corresponded to what Miles and Huberman (1994) call data reduction. Different researchers have different approaches to data analysis. Tesch (1990) called the process de-contextualisation and re-contextualisation, whereby data is coded and analysed in terms of smaller units and regrouped in terms of patterns and trends. Hatch (2002) has come up with four models for doing qualitative data analysis. Common to all the approaches is that the bulk of the data is broken down to help give meaning. The strategies followed to represent the process of data analysis to the end product of making conclusion is best displayed using the model suggested by Miles and Huberman (1994).

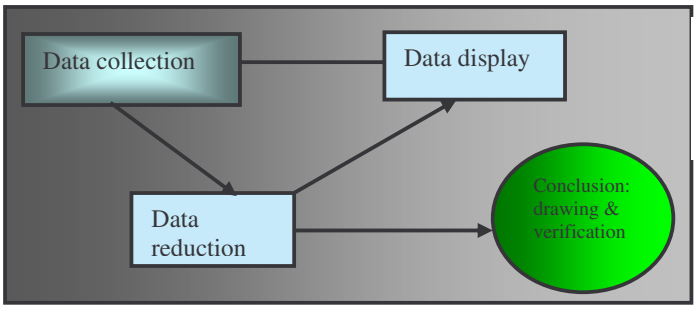


Figure 4.4: Data reduction process (*Source: Miles and Huberman (1994)*

The above diagram gives the core to their model showing a link between the four steps involved in data analysis. The process occurs at various stages of the research study. There are various procedures one can apply at data reduction step to disaggregate the large volumes of data into manageable units.

Reducing the Data from the Interviews and Classroom Observations

In this study, the typological approach to data analysis proposed by Hatch (2002) was adopted. The data which was collected from various sources such as teachers' interviews and classroom observations was reduced through various steps indicated below.

1. Identification of typologies (categories) to be analysed
2. Read the data, making entries related to the typologies
3. Read entries by typology, recording the main ideas in entries on a summary sheet
4. Look for patterns, relationships, themes within typologies
5. Read data, coding entries, according to patterns identified and keeping a record of what entries go with elements of patterns
6. Decide if patterns are supported by the data, and search the data for non-examples of the patterns
7. Look for relationships among the patterns identified
8. Write patterns as one sentence generalisations
9. select data excerpts that support the generalisations

Figure 4.5: Steps in typological analysis approach to reduce data analysis

Source: Hatch (2002)

According to reviews, the steps are not necessarily linear as they can occur before data collection, during the study design and planning, during data collection as interim and early analysis are carried out, and after data collection as final products are approached and complemented (Miles & Huberman, 1994; Hitchcock & Hughes, 1995).

Procedures Followed to Generate Categories

As stated in figure 4.4 above, the core of this model is the importance of identifying the categories followed by dividing the large volumes of data into the premeditated categories. In this study, categories used where based mainly on the dimensions found in the Rogan and Grayson (2003) profiles of implementation and capacity to support innovations. In addition to these categories, I devised a coding system, derived themes, and patterns and clustered them as new categories for each teacher, school and eventually an all school's grouping. The coding was accomplished through subjecting all the data to the ATLAS.ti programme (discussed later).

The category on capacity to innovate was used to generate interview and general school observation data. These data were hoping to find how much infrastructure the school (science department had), as well as other factors that may influence teaching and learning, making the school set-up such as teachers commitment to work, knowledge of curriculum demands as well as the school environment such as the flow of teaching activities, involvement of teachers in the running of the school, inclusion and sharing of school vision.

Another broad category concerned the implementation of the BGCSE curriculum inside the classrooms. In this study it was broken down to two main categories concerning what is happening inside the classrooms. That was to find the extent to which teachers were now oriented in their teaching approaches towards learner-centred teaching and learning. Another sub-category was based on the implementation of activity-based kind of teaching and learning and specifically the extent to which learners participate in performing practical work.

Using Categories

Using categories seemed the most appropriate approach because a large part of this study relied on the semi-structured interview as a primary data collection tool. This made interviews to have a fairly focused purpose and well structured data set in terms of organising or guiding questions. In this regard the study offered logical places to start looking for categories on which to anchor analysis. The interviews in this study looked at the teachers' perspectives of the change of curriculum, and teaching as I was interested in relationship between what the teachers believed and what they did in their classrooms. Though I did not ask direct questions, a series of guiding questions were developed that gave opportunities to discuss the thinking behind their work in addition to asking them to describe the work itself.

In analysing the interview transcript for teachers relating to curriculum change and their teaching philosophies, it was different from analysing issues related to implementation and capacity to implement because the categories were not so obvious as in the theory of implementation by Rogan and Grayson (2003). The first typologies identified 'teachers' beliefs and teachers' practices. Sub-categories included

- classroom organisation
- goals and objectives
- types of teaching and learning
- types of interactions
- learner's tasks
- instructional delivery
- approaches to learner-centred activity based teaching and learning

Following the identification and setting up of categories, the data was now read with the categories in mind. Since ATLAS.ti programme was used up to this stage, it was easy to mark places in the data where evidence related to a particular typology was

found. The programme also helped to merge and or separate data categories according to related evidence or codes given. In this step I was basically simply separating the larger set of codes into the smaller families.

In the interview component, concerning the teachers' perceptions, and about curriculum change and practices, I began by reading the data looking for the places that teachers' perception about curriculum change were evident, then followed by perception about the actual practice. The same procedure was followed for all the typologies.

It was at this point that processing of information within the typologies was related to typology and new family codes within the typology created. A summary (sheet) was created for each teacher, as main ideas of the excerpt and codes were made. Use of ATLAS.ti programme made it easy to trace where the data was coming from, an important step to help refer back to the original data when the need arises. Further identification process was done using given names of teachers interviewed. All protocol pages numbered as it made it possible to record a place in the data by noting the interview or field notes name, with data and page number.

4.6.2 Looking for Patterns, Relationships and Themes within Categories

Having drawn up summaries and brief statements concerning the typologies and family codes created, it was time to start looking for meaning within data. Use of typological analysis made it possible to have ideas going into this step of the kind patterns, relationships and themes that could be present in the data. The typologies I had selected helped in the kind of search about the dimension present in the data (Rogan and Grayson, 2003). A summary of the steps followed is shown below;

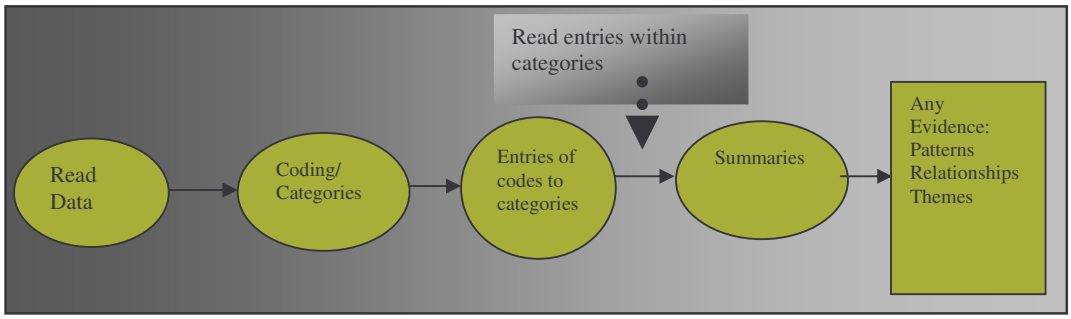


Figure 4.6: A summary of steps taken in interpreting data

From the summaries it was possible to start seeing patterns, relationships and themes. Patterns were obtained from the data by looking for regularities within the categories (Hatch, 2002). According to him, searching for regularities basically meant looking for similarities, differences, frequencies, sequences or causations. This was done using data within a school about the school, the individual teachers and between teachers. Search for regularities was also done between schools.

Generating Categories

At this stage, it was necessary to make judgment based on the data on whether the categories were justified by the data, checking whether the coded data fitted into categories I had. This part also involved the issue of deciding if the data not coded contained insights that are different or contradictory to what was proposed. Since a computer programme was used for coding, all the data was coded and even part of which did not relate to the categories and it helped to check the memos, and unused codes to confirm this. Having drawn patterns within teachers' interview and classroom observation data, and other data concerning the school, it was also necessary to make links or relationship between the summaries created. This is accomplished through scrutinising the codes and quotations, summaries and patterns for rationale behind certain issues, cause effect or generally the reason why certain things happens, association of certain issues or occurrences with schools and teachers.

Checking whether patterns were supported by the data was carried out for all the initial categories identified. Checking helped to look for connections across what has been found. This process was enhanced by making visual representations of the categories explored in the form of figures, tables, then looking for what relationships might exist between or among categories (Hatch, 2002). This process is described as data display (fig. 4.4) by Miles and Huberman (1994).

Themes according to Hatch (2002) are considered integrating concepts as they carry meaning that runs through the whole data. These were crucial statements in this research since the study is a multi-case study. Each case needed integrating or generalising statements, to summarise each teacher and each school, which could be described as sub-generalisations (Miles & Huberman, 1994). Sub-generalisations

were made at the end of every chapter as each school or case was analysed separately. The individual teacher or school generalisations mainly touched issues such as modes of instructions, perceptions and beliefs about curriculum change. These helped to pull the whole case together. Further generalisation statements integrating all the reviewed schools then followed. With the help of the tools provided by the ATLAS.ti programme, I searched for excerpts that supported the generalisations.

4.6.3 Use of Software in Data Analysis

ATLAS.ti is one of a new generation of qualitative data analysis software packages. The software can be used to analyse textual types of data such as interviews and field-notes and other types of digital formatted data (Opie, 2005). Digital formatted data include such data coming from images, audio recordings and video which can also be imported into the hermeneutic unit just like text documents (Opie, 2005).

Working with Textual Primary Documents

One of the common operations involving working with textual document includes marking segments, assigning codes and making family codes. Use of the software to code data makes it much easier to handle data due to its ability to support networking. For instance, any of the documents imported to the hermeneutic unit such as the primary documents, codes, quotations and memos created can be linked. The ATLAS.ti software allows for creation of any type of link through a variety of relations dictated by the data or analyst. Such connections of data could be making a link such as 'is part of'; 'is a cause of' or 'is a property of' (Opie, 2005). Quotations can also be linked in the same manner to show relations that: 'justifies'; 'criticises' or 'explains' or in any form as dictated by the data or interpretations made by the analyst. This was mainly done in the findings' chapters. In a nutshell, the software helps an analyst to perform what Mills and Huberman (1994) described as data reduction and re-contextualisation. The re-contextualisation process occurs when the data in smaller units is treated or regrouped in terms of patterns or trends made by analyst, under larger names called families or categories.

Role Played by ATLAS.ti in This Study

In this study the major part played by the software mainly involved three process of creation of quotations, coding the documents and to some extent creation of family-codes. Creation of quotations followed soon after importing the documents into the programme, which involved marking segments of the documents and given a code name. As indicated earlier, most of these segments related to categories found in the three constructs found in the theory of curriculum implementation (Rogan & Grayson, 2003). Following the creation of various codes, it was possible to group those whose quotations had similar meanings or followed a particular pattern or trend.

An example representing some steps involved in organising data is shown below. Due to the ability to network data, it was possible to make various network links such as showing the nature of data coming from the teachers, their classes observed and eventually the school. An example of such simple link is shown below.

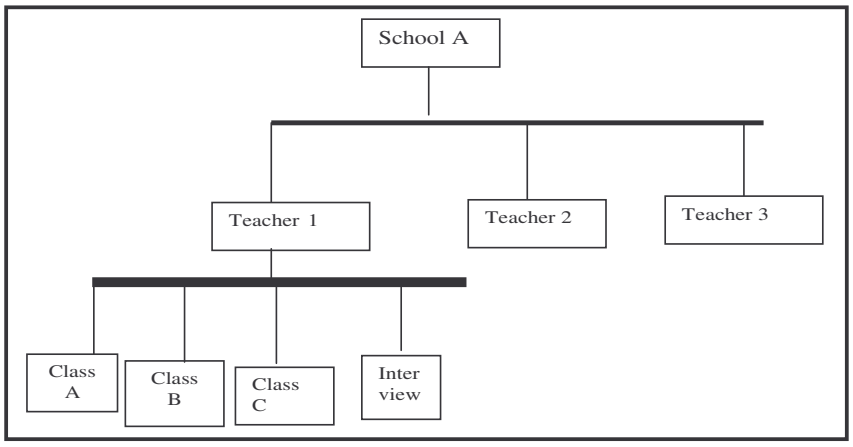


Figure 4.7: Hierarchy in generating and regrouping codes

The data came from lesson observations and interviews but had to be transcribed into textual-format first. The figure above shows links before codes were created. Another figure 4.8 given below shows the nature of links that could be drawn involving one teacher and his/her practice. First the codes from a teacher's practice were regrouped (still linked to their quotations) according to the broad sub-contracts of the theory of curriculum implementation as shown below. Such network diagrams are also a representation of my thinking about the data and how the patterns relate to each other as strategies, contexts and casual conditions.

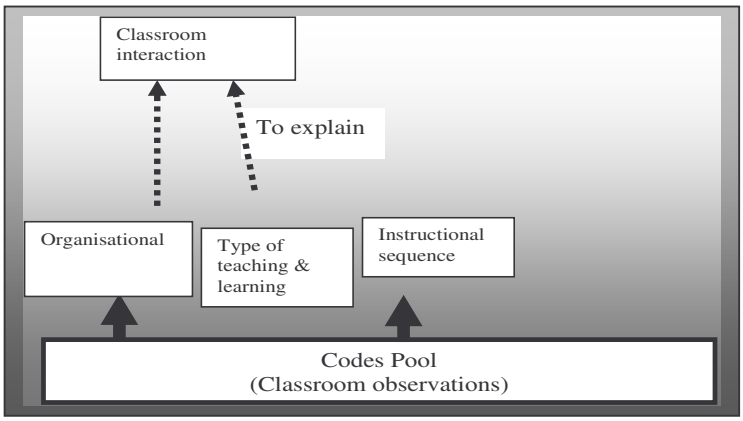


Figure 4.8: Constructing categories

Summary of Steps Taken

Following the strategies described above, various patterns, relationships and themes emerged as a result of reduction of the interviews and observational data. Some were constructed by the investigator through the process of induction (Hatch, 2002; Marshall & Rossman, 1989) whilst some of the categories related to Rogan and Grayson (2003) sub-constructs. These related to various aspects of BGCSE concerning perceptions, teaching and learning, e.g.:

- The convergence and divergence of how the different teachers (schools) conceptualised implementation of the BGCSE
- The effectiveness of the BGCSE chemistry teaching by individual teachers
- Teaching and learning chemistry through learner-centred methodologies, activity-based learning
- The incorporation of practical work in teaching chemistry
- Patterns, relationships (trends) and themes relating the lessons in chemistry presented by: (1) a teacher and (2) teachers in the school
- Patterns, relationships (trends) and themes on the relationship between teaching the BGCSE and the teachers in a school, the science department; the physical resources; the school ecology and management

4.6.4 Drawing Conclusions

Generating meaning from data can be seen as following the pattern of descriptive to explanatory and from concrete to the more abstract (Hitchcock & Hughes, 1994, Denzil & Lincoln, 2006; Miles & Huberman, 1994). This implies that meaning

becomes more apparent if one begins by providing detailed descriptions from raw data and then moving on to description and development of a theory from the field. In this study, various strategies to verify, confirm and to conclude the findings were employed. This included such processes as counting, noting of patterns, relationships, themes, and finding mediating factors, and building a logical chain of evidence (Miles & Huberman, 1994). Part of drawing of conclusions and verification of data also consisted comparing and contrasting the views and practices of teachers per school, establishing or rejection of the finding by investigating the possible reasons for varying perceptions held by teachers about the BGCSE curriculum.

Though processes such as counting were done, it still remained a non-frequency approach, also called non-quantitative (Lincoln & Guba, 1985). This approach was used because it relies less on the frequency with which a particular action, word or code occurs in communication or text. The approach mainly focused on mere occurrence (or non occurrence) of attributes for the purpose of making inferences. Hence, relying on this model meant placing less emphasis on the number of time particular assertion, or codes occurred on finding out whether assertions or themes occurred (Tesch, 1990). In view of the methods used to collect the data and nature of data sources, this type of approach to analysis was considered appropriate in this research study. This was so because it provided me with practical strategies for clustering the data collected from teachers in each school and also helped in drawing conclusions from the data. In accordance with its characteristics of the approach, issues, themes and patterns regardless of the number of times they occurred in the data collected were recorded. Further approaches were applied in this study to help build conclusions such as triangulation, weighing of evidence, making contrasts and comparisons, using exceptional case to account for regularity (or lack of it), and checking out for rival explanations. Since comparison of teachers within a school, teachers between schools, similarities and differences could be accounted for through use of exceptional cases or occurrences in different schools.

The tactics to help confirm the data by Miles and Huberman (1994) were useful not only for verification and confirming the data but also concerning issues of blatant biases. Counting helped to construct figure and tables concerning teaching approaches, observed practical session from chemistry lessons. The tables and figures

helped in drawing conclusions and verify data in terms of frequencies, coding, and assertions. Noting of patterns, relationships, trends and themes forms major component of data analysis in qualitative research studies. Also equally important in drawing conclusions, was the method of triangulation. Data triangulation was used extensively to verify classroom observation and interviews. Investigator triangulation was also used through critique by peers (fellow doctoral students during seminars). In discussing the analysis processes, the reflections provided some information that helped shape working with data and the suitability of the codes. It is important to note that the author had two supervisors who checked the data, the analysis and coding patterns at all stages.

Comparing and contrasting data from classroom observations with interviews, teaching of different streams, by the same teacher, different teachers in the same schools and doing the same across different schools aided in presentation of results. This way views, perception about the school, chemistry departments' ecology and management, the new curriculum could be compared to explain or relate to teaching and learning (by a teacher, between teachers in the same school, between schools). Checking of rival explanations became important also in this regard, especially in confirming or discounting findings between schools.

4.6.5 The Indicators in the Theory of Implementation Framework

The use of the theory of curriculum implementation was two fold. First the constructs (and their sub-constructs) were used to guide data collection in the classrooms. The framework was also used in analysing data. It has been mentioned above that the family codes were basically the sub-constructs found in the framework (Rogan & Grayson, 2003). To help make sense of the data, it was important to include another step of determining the operational level of the teachers and school. It has been mentioned above that the tables and figures helped in drawing conclusions and verify data in terms of frequencies. This was applied in coming up with operational levels. Equipped with operational levels, it becomes possible to identify the possible ZFI for the school. Determining the operational level for teachers involved matching the classroom practice indicators for teachers to the operational level from Rogan and Grayson (2003). This is explained further in chapter 5 and chapter 6. A complete

template modelled under the Rogan and Grayson (2003) framework, showing the scales and its indicators for Botswana schools has been portrayed in Appendix A.

Summary

Chapter 4 had two main sections. The first section looked at the relevance of the case study approach in this study which was discussed and justified. The description of the research design which included procedures and strategies adopted in the pilot study were looked at. A brief report of the pilot study was also made, including its influence on the data collection strategies. Sampling procedures for the main study were discussed and justified. This includes issues of validity and reliability appropriate to the study.

The second section of chapter 4 examined the approach used in this study to collect data and to analyse the two main data from the interviews and the classroom observation. The analysis followed the model proposed by Miles and Huberman (1994) to analyse and interpret data. The data reduction process followed a typological analysis approach proposed by Hatch (2002). This strategy involved generating or identifying categories. The first part of the data which concerned interviews mainly concerned the usage of categories articulated by the teachers or coming from data. This was especially true concerning teachers' perceptions about curriculum change, policies and intentions not necessarily found under the sub-constructs in the theory of curriculum implementation by Rogan and Grayson (2003). The second part of analysis was concerned with the generation of meanings relating to classroom practice and capacity to innovate. The categories mainly related to Rogan and Grayson's (2003) sub-constructs. The typological process by Hatch (2002) was complemented by the procedures from Miles and Huberman (1994) concerning drawing of conclusions. All these strategies for drawing and verifying conclusions were described and justified.

Following the description of the research methodologies and analysis procedures followed in this study, it was now time to give a general description of the school contexts found in the Republic of Botswana.

CHAPTER 5 SCHOOL STORIES

Introduction

The main goal of this chapter is to paint an authentic picture of the setting of each school, the teachers and their work with learners. The field notes provided an account of my interactions with each of the teachers in the chemistry department and a description of their work place and even their thinking. But it is evident from the descriptions that my portraits were inevitably influenced by my own background as a teacher and familiarity with the schools and teachers. The schools to be described in this chapter are named Domboshaba, Tagala, Maru and Lesedi Senior Secondary Schools (SSS), in a format which I call the school stories. Each school will be portrayed individually in the order they were visited. This is the same order in which findings are presented in the subsequent results chapters.

Description of Portrait Use

According to Hitchcock and Hughes (1995), a portrait is an area usually associated with the systematic representation of a true picture in photography or art. In recent years were it is possible to present texts as cultural artefacts, it therefore extends to qualitative studies as it can be used to convey information primarily through writing. The textual base to represent a true picture enables a successful communication of experience with what was seen and heard (Hitchcock & Hughes, 1995). The descriptive text wants one to picture and visualise what was described.

A school portrait in this study was taken as a representation of a school, in which its face, characterised by its setting such as the infrastructure and how it operates is visualised by the researcher and those within the school. The intent was to display the likeness, personality and even the mood of the teachers. For this reason a portrait is not just a snapshot, but a composed image of many items making up the school. This was to help to successfully engage the reader in the subsequent chapters on findings concerning implementation of chemistry.

The choice of depiction to make the story was mainly supported by the Rogan and Grayson (2003) profile of the capacity to support innovation. The sub-constructs

which were of interest, and were used in the school portraits dealt with the physical resources of the schools, teachers and learner factors, the school ecology and management. The representations were chosen because of how they link with implementation inside classrooms. Thus the portraits will be useful in interpreting the findings inside classrooms that is to do with which of the factors in the school had influence in the implementation of the BGCSE chemistry curriculum. There are arguments that well resourced science departments should translate to full implementation of new curricula. Portraying the physical and human resources the science departments have and specifically those related with teaching of chemistry, and other factors from Rogan and Grayson's (2003) theory of curriculum implementation will help link which of the factors impacted implementation in Botswana classrooms more.

Other school characteristics in these stories refer to those factors about the school that could have had an impact on classroom practice, such as the environment (locality), size, composition and the school's management system. The main data sources for this chapter were direct observation, informal chats and teacher interviews. Direct observations helped provide information about outward appearance of a school and class sizes.

School climate factors were also considered in the portrayal. That is the role played by the principal, school management (administration), the way teachers related to one another, especially in the science department and specifically in the chemistry section, the classroom and laboratory and their appearance. Hence, the portrait was an amalgam of various settings, images, and infrastructure.

The table below attempted to give a summary of facilities common to all the schools, mainly related with teaching of science and specifically chemistry.

Table 5.1: An inventory of physical resources at the four secondary schools

		Domboshaba SSS		Tagala SSS		Maru SSS		Lesedi SSS	
	Physical Resources	**Availability**	**Condition**	**Availability**	**Condition**	**Availability**	**Condition**	**Availability**	**Condition**
1	Classrooms	Not Enough	Very good	Mixed- old/new	Some need renovation	Enough	Very good	Enough (mainly old)	Fair
2	Science Laboratories (Chemistry)	10 ***(3)***	Excellent	11 ***(3)***	Excellent	10 (3)	Excellent	10 new (2 old) (3 new)	Excellent
	Computer labs	1 centralized	Excellent	2- centralised	Excellent	2	Excellent	1 centralised	Excellent
3	Chemicals	Available	good	Available	adequate	Available	adequate	Available	Good
4	Apparatus/ equipment		good	Available	adequate	Available	Adequate	Available	Good
5	Books	Available		Available	Distributed to learners	Available	Adequate	Available	Good
6	First-Aid kit	Available	good	Available	Good	Available	Good	Available	Good
7	Fire extinguishers	Available	good	Available	Good	Available	Good	Available	Good
8	Furniture- Tables Demonstration tables	Available	Good	Available	Good	Available	Good	Available	Good
9	Storage lockers Storerooms	Available	Not used	Available	Good	Available	Good/ used	Available	Good
10	Notice boards/ Charts	Available	Bare/no posters	Available	Half empty	Available	Used	Available	Good
11	Workstation: Sinks /electricity/gas/water points	Available	Well resourced	Available	Well resourced	Available	Well resourced	Available	Good
12	Fume hood	Available	good	Available		Available	Good	Available	Good
13	Audio visual Aids: projectors/posters etc	Available		available	Posters- not mounted on walls	Available	Good	Available	Good
14	Photocopying facilities	Available- centralised		Available- centralised	Large-	Available – centralized	Good-limited access	Available- centralised	Good

All four schools were large and of comparable size in terms of learner and teacher populations (table 4.4), science departments and chemistry section capacities. All government senior secondary schools take care of the last two years of secondary schooling in Botswana, known as form 4 and form 5. Each school had about 21 classes per form, with class sizes ranging from 30 to 36 students. The first school I visited was Domboshaba SSS and its characteristics will be discussed below

5.1 DOMBOSHABA SENIOR SECONDARY SCHOOL

5.1.1 A Portrait of the School from my Observations

Below is a description of the school setting, the resources, the role played by the management system in the school and the way teachers, especially science and chemistry teachers related and worked in institutionalising the BGCSE innovation and change.

General Description of the School

Domboshaba Senior Secondary School (SSS) was one of the four most recently built senior secondary schools in Botswana. It differed significantly from the older schools. The buildings were well designed, the layout of classrooms, laboratories and the administration blocks are well planned. In 2000, all older schools in Botswana were upgraded. Prior to this, Domboshaba was the most envied school by both teachers and students in the country due to its infrastructure. Compared to the other new schools, it had started performing well in both academics and sports. However, all schools in the country are now of comparative infrastructure, especially for the practical subjects like home economics, fashion and fabrics, art, sciences, design and technology. All these departments had been rebuilt. Revamping the schools meant that older schools consisted of a mixture of modern buildings and old structures, which retained a bit of their originality. Domboshaba had only one type, and all the blocks were built from reddish stock-bricks or painted light brown. Most classrooms are two-storey blocks.

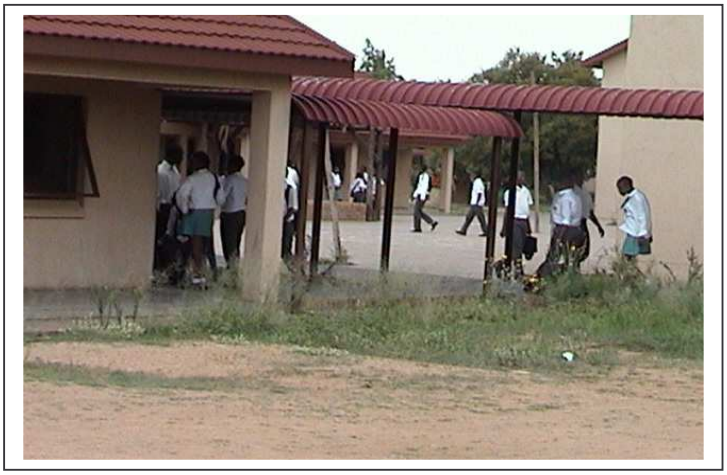


Figure 5.1: Domboshaba SSS science section

As far as cleanliness goes, the inside of the school looked well kept, due to regular clean-up by students. However, the classrooms were no longer in a state of good repair from inside, because students had damaged desks and electric sockets. In each block there are two mini-staffrooms for teachers of that department. Most teachers use these departmental staffrooms, because the main staffroom, though air-conditioned, is too small to house even a quarter of the teaching staff. In the main staffroom there is a computer and a printer as well as some sofas and pigeonholes for all the teachers. Teachers mainly come here during the day when they are free to pick mail, rest, sleeping on the sofas or to use the computer.

Flow of School Activities

Domboshaba SSS had a student population of about 900, making it the smallest in this case study. Punctuality in the morning was enforced, as could be seen by the teachers on duty who discipline latecomers at the pedestrian gate. Teachers on duty could always be recognised by the sticks they carried during school hours. School activities started with an assembly where various activities such as singing religious and cultural songs by students, prayer, announcements or students presentations were conducted. Lessons commenced soon after assembly. On Wednesdays, lessons started early as there was no assembly, allowing for cleaning activities soon after afternoon study.

Form 4 learners in the country start the term late, about three weeks after the beginning of the term as the screening form 3 final examination results are not released until January. After their arrival, it took some time before their timetables

were arranged which made it impossible to involve them in the study during the first two weeks of observations. School authorities said this was due to result of logistical problems such as selection of students for subjects especially streaming for sciences. The form 5 learners opened earlier and had been in school for about four weeks. Their timetables were already in place. This meant that the form fours spent close to three weeks in this school without any formal teaching.

It was during my stay at this school that the examination results of the previous form five were released. Overall the school had done well, teachers were happy that they had attained a respectable '*position four*' out of 27 schools in the BGCSE national league. There was a lot of talk in the science department about the results. Some critical teachers thought that the school had been declining to mediocre levels, especially since the school admitted the best students in the region. Their expectations were higher.

The Science Department

The science department was isolated from the rest of the departments. There are two blocks, one housing the physics and chemistry sections and the other biology. All biology teachers are based here. The biology section was very neat and in a state of good repair, including the posters, cabinet doors, drawers and water and gas taps. The other block houses six laboratories, which were chemistry and physics specific. In the centre was a space designed for laboratory preparation purposes, but it was used by teachers as a mini staffroom. Some of the teachers use spaces between the entrance to the laboratory and the preparation room as mini offices.

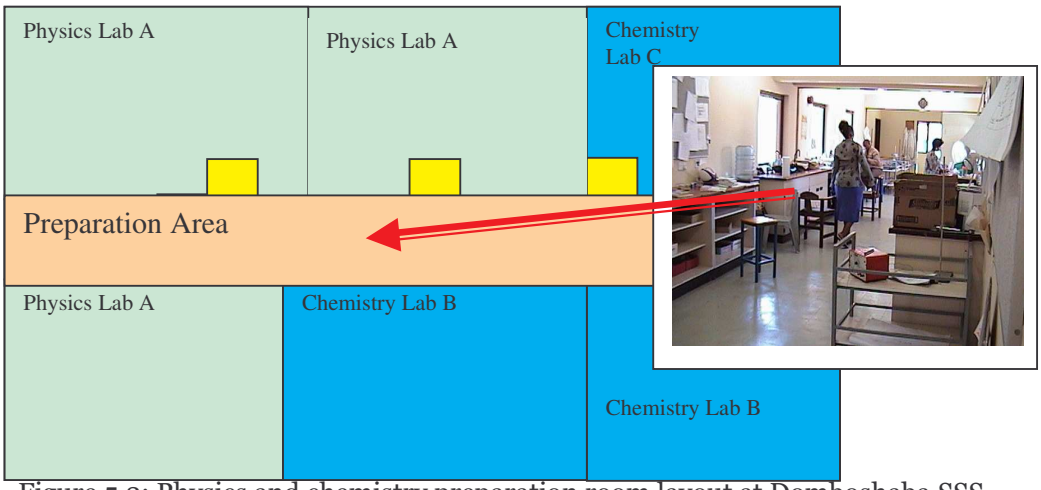


Figure 5.2: Physics and chemistry preparation room layout at Domboshaba SSS

I found settling in the science department easy because I already knew teachers like Mr Kenosi, Mr Osman and Mr Baliki whom I schooled with at the University of Botswana. As a pre-service teacher I had done my final teaching practice in this school in 1996. But other members of the department from that time have since changed and all the chemistry teachers that I knew had left.

My first contact with the school was through the Mathematics and Science HoD, but it was the science senior teacher and the chemistry coordinator, Mr Sharma who showed me around and introduced me to the chemistry teachers. Mr Sharma, who is from India was not comfortable to participate, his preference was that I work with the young local teachers. The youngest teacher in chemistry was not too comfortable with participating, but the other three teachers, all of comparable teaching experience were happy to participate. These teachers were Mr Kgabo, Mr Pula and Ms Malane.

Activities in the Department - Interactions

The chemistry and physics teachers spend a lot of time working in their preparation room. Activities in the preparation room included discussions of marking keys or questions for tests due to the fact that the department gives end of month standard tests. Having many tests meant teachers spent most of the time in here marking. The area was also used to prepare experiments and store teaching materials. Trolleys could be seen, loaded with physics or chemistry experimental setups. Teachers and the two laboratory assistants were often seen engaging in preparations for practical work. All the teachers observed told me that whenever a topic lent itself to practical work, they always tried to organise one. During tea break, teachers organised their own tea in the preparation room with all the physics-chemistry teachers taking part in the tea-club.

Disciplinary Committee

Science teachers also chaired and managed a small student disciplinary committee. The science teachers felt that this was necessary since the school did not care much about controlling student behaviour. They felt that students' lack of focus on school issues resulted from poor discipline. The committee sat each time a disciplinary issue was reported and punished students.

Resources of the Chemistry Section

Domboshaba School has a shortage of classrooms which has resulted in the laboratories being used as base-rooms. About seven form-four classes have been accommodated in the science laboratories which is problematic as students now have full access into all parts of the science laboratories. In spite of use of laboratories as student base-rooms, internal fixtures were still intact apart from the few broken pieces of furniture. The type of facilities the chemistry section had is shown on table 5.1 and figure 5.3 below.

Figure 5.3: A typical chemistry laboratory at Domboshaba SSS

Table 5.1 (in pg 101) portrays a picture of some of the general resources found in the school especially those related to chemistry teaching. The table shows that Domboshaba SSS has good chemistry resources. All the three chemistry laboratories are the same with comparable fittings which include a fume hood, storage facilities such as wall cabinets, a shower and a storeroom attached to each laboratory. However, due to use of these laboratories as base rooms for learners meant that items like commercial posters, chemicals and all the apparatus (glassware) had to be removed, leaving all the laboratories empty except for trivial attachments like sweeping rota.

5.1.2 A Portrait of the School from the Perspective of the Teachers

The perspective of the teachers concerning the school resources was sought through, informal talks and interviews.

Science Resources

The interviewed teachers Mr Kgabo, Mr Pula and Ms Malane were happy with the general chemistry resources, considering that resources such as teaching aids, apparatus and chemical were enough for day-to-day teaching. For instance Mr Kgabo said about the availability of resources '*Here I think we have enough teaching materials…' (Kg*abo interview, pg 2). Ms Malane also reiterated this, saying

> …it's ok. It only depend on the teacher, whether they really want to prepare (experiments) for the students (Malane interview, pg 5)

Although the number of laboratories was considered adequate with proper timetabling, a major concern was with shortage of classrooms which have seen laboratory security compromised. Mrs Malane said '*…like you can see our labs are used as base rooms' (*Malane interview, pg6). General use of laboratories by learners meant that valuable or breakable items cannot be left or kept in the laboratories anymore. Ms Malane said,

> So it is very difficult for us to keep certain things in the labs…some of these teaching aids really we can't keep them in the labs…we do have like the flip charts for the periodic table… charts having different topics around 8 or so… we keep them in the storerooms (Malane interview, pg 6)

The new arrangement meant that students could enter and use the laboratories any time during school time, contrary to the rule that the laboratories should be locked at all times and out of bounds in the absence of a teacher. Lack of supervision has resulted in damage to some items in laboratories like water and gas taps, some electric sockets and cabinets which are now used by some students to store personal belongings like books. Some cabinet doors are broken, including damage to fixtures such as fume hoods which are said to now malfunction.

> Looking at things like our fume-hoods, well they work but some of this experiments that we try to use to show diffusion and others like Chlorine gas, these are things that now I have even taken a decision that I will not do them anymore, but I know the students are going to suffer (Malane interview, pg 12)

Although resources seemed a concern in the day-to-day teaching and learning, teachers at Domboshaba SSS were also concerned with the impact the management systems, and issues related to how the school functions.

School Ecology and Management

The teachers talked a lot about the way they viewed management in influencing the functioning of the school. An important point made was that there seemed to be no strong leadership. They linked the flow of activities with the management especially its instability and lack of influence lately. The science department is a close community, with a lot of autonomy in running its affairs. As a very stable and organised community, teachers generally felt that the rest of the school is not functioning as well as it should.

Domboshaba SSS, in the past used to be one of the few well resourced schools in the country compared to the old schools. Ms Malane said about the school, '*when I came here coming from Kasane SSS, it was like I was teaching in a University'* (Malane interview, pg 9). The interviewed teachers thought the school used to be highly rated due to its excellent infrastructure and strong leadership, but a continuous change in leadership in its short history had left the school lacking continuity. For instance Mr Kgabo said:

> …from 1999…it's like we didn't actually have a good administration because the headmasters kept on coming in and going you see. Actually our administration is not that stable because of the changes from time to time…going …on promotion all of them you see… it actually affect the way the administration should work…I mean (currently) somebody (is) acting as a deputy, another as a head … both acting you see (Kgabo interview, pg 9).

The present principal and his deputy are temporarily acting until the end of the term (first trimester). Such a high turnover with administrators has led teachers to think that even good innovations had never been implemented due to lack of continuity (or follow-up). Mr Kgabo gave an example of annual plans which raised expectations of stability in performance and improvement in ways of doing things at Domboshaba:

> It's like the person who was so particular about this …strategic planning was the first head master of this school…he knew what he was doing you see. But it is very difficult for the new ones because actually to continue the strategic plans that he was planning. So to them… it's just a paper (work) …Nobody will ask you those questions… (Kgabo interview, pg 5)

The instability has not helped in fostering a strong relationship between the school leadership with teachers in general. For instance, the science teachers felt that the administration was either disregarding disciplinary issues or taking the side of the learners. Hence, they formed their own disciplinary committee within the department

to help cultivate functionality. The committee sat each time a disciplinary issue was reported. In most cases, the student would receive a beating plus having to clear grass on the school premises. Teachers continue to feel that learners are rated above them, who at times are not informed about issues concerning learners. The current principal preferred communicating directly with learners.

Teachers felt that the easier alternative would be to ignore the situation, knowing the repercussions of use of corporal punishment. The view that if no one gets involved *'... the students fail …you have problems'* (Kgabo interview pg 7), forced some to take a stand. As Ms Malane said:

> …if you have like problems with students in class, or class control or some things… students are not behaving, there is nobody above you who is helping you… get the students to the right behaviour you see. To help you get the kids know why they are supposed to behave and focus in learning… you are struggling in class you want to teach, the students they don't care, because they don't know why they are here. There is no role model (administration), here to help kids to know that they are in school, and they have come to learn. (Malane interview pg 9)

Since learners knew the administrators will stick to the policy of discouraging use of corporal punishment they protest and take the issue to higher offices:

> … when you try to beat him/her and say 'no, if anything lets take the issue to the admin'…because they know at the admin they will be saying no … the school policy is … the ministry says you can't beat a student… (as) a teacher. It's only (certain people) who can do that… (Malane interview pg 12)

The science teachers generally don't think it is right for the administration to take the learners' side, at the same time offering no working alternatives.

> It's not right in the sense that from there you are the same teacher who is going to continue teaching this student you see. Who by now has lost confidence in you, that you, you cannot control him, you are a powerless somebody, so it's going to be difficult to now teach this kid to make him/her pass. You end up isolating him, saying ah, he will be taught by those. (Malane interview pg 13)

As individuals they knew they would have problems in disciplining learners, as corporal punishment was one of few modes viewed by most teachers as effective concerning correction of learners. The department decided to make it a collective responsibility which gave them a bigger voice over learners. Teachers felt that

learners conducted themselves better when they are within the science premises. The teachers thought that the over relaxed atmosphere was affecting both learners and the teaching force negatively.

> …at times I feel people do get a lot of laxity really… in school. And in that case you find that it favours us that is, because you can run around and do your own things outside (school). Because, really here, you will find that if you're out (of school)…. Nobody will ask you, where were you period five and six, if you missed your class. Nobody! (Malane interview, pg 9)

Teachers in the department end up doing the right things, not for the school but for their senior science teacher.

> …. at times of course our senior teacher here we do things humbling ourselves because of him. Because him, we can see, he is responsible, he wants us to do that, and again he is not very bossy you see. He is somebody who really understands (Malane interview pg 9).

The science teachers generally thought that the administration was not supportive enough. For instance some of the initiatives they had proposed to improve their work had been disrupted. Due to the large demands of paperwork for tests, assignments and teaching, the science department suggested having its own printing and photocopying facilities. An attempt to source funds from outside the school to buy equipment for the department was blocked. The administration felt that it would be too expensive for the school to finance the repairs and consumables. Such a move left science teachers frustrated by the lack of support. The teachers thought it was to stop them from being too autonomous.

Further signs of strained relationships include issues surrounding communication with teachers in general. Teachers thought that in this school '*it's like students come first and then teachers second' (*Malane interview, pg 13). Ms Malane gave an example of the decision by the administration to cancel the Saturday morning studies saying:

> I don't know why it was cancelled. But to us (teachers), we met that at the assembly when students were told that we have cancelled the study. We teachers never got to know it was to be cancelled (Malane interview, pg 13)

Ms Malane was giving this as an example of the lack of collegiality between the school leadership and the teachers. She thought that the communication gap was not enhanced by preference for 'arm-chair' governance. This was so because according to

her, the school leadership spent most of the time in their offices, interacting little with teachers. The result was that teachers don't get to '*know what they have in mind when they are in there* [their offices]*' (*Malane interview, pg 9)*'*.

Motivation of teachers

The teachers linked their motivation to work to the way they associated with the administration. Ms Malane voiced the opinion that the presence of the principal was not felt strongly enough in the school, 'as *far as the administration is concerned, we know it's like there is nobody there' (*Malane interview, pg 9). The result was that the administration was not accessible. For instance, if

> …you have problems with students in class … there is nobody above you who is helping you to get the students to the right behaviour you see... (Malane interview, pg 9)

Ms Malane's view was that such lack of support '*kills it in a way' (*Malane interview, pg 9*)* referring to the morale to teach. Though the teachers felt unsupported by the school administration, the cohesion and support within the department helped them stay focused when it came to teaching.

Support from the Science Department

The interviewed teachers spoke of various structures within the science department that helped them cope with teaching and other challenges. The general feeling was that the science department tried to bring order in the department to enhance learning. This involved bringing discipline in the department (already discussed). Teachers had also come up with a timetable for common science tests on a monthly basis. Such plans required more teacher coordination as teachers now use a common teaching scheme which they prepare together. Mr Kgabo also talked about support in terms of teaching, that teachers are free to approach one another when faced with difficulties. He said

> Like last term we were teaching a single science class across (integrated)…we could even ask another teacher to come and teach for you… to see how … this thing should really be done (Kgabo interview, pg 3)

Ms Malane agreed that most of her colleagues have no problem teaching for others and said that they now want to extend collaboration to peer observations,

> Some of us really don't have any problem. I remember just a few weeks ago talking about it that I think even, we should improve or support team teaching you see. Like there are topics that if I feel…I am not very good in it I can ask a colleague to go and teach…But were a teacher can just come in at times… we normally do that, like at times finding Mr Kgabo doing a practical, I go in and help. Sometimes I don't even ask for permission, I just walk in and finding a student I recognise to have a problem…I help her (Malane interview, pg 7)

Teachers' Perception about Constraints

Though the teachers said the chemistry department of Domboshaba SSS have enough resources to teach well, they felt that they faced constraints in implementing the chemistry curriculum. The major constraints were cited as too many classes which hindered good teaching

> At the moment I am going to be having eight different classes. To go to class and lecture will not be a problem you see. But eight classes, how do I arrange for their practicals? How do I mark the tests? By the way it means eight piles every month, for monthly tests… How do I mark homework for eight classes? (Malane interview, pg 5)

The teachers thought that this problem was compounded by the fact that the department had changed from teaching the single and double science curricula as an integrated subject. Instead the three components were taught by 3 different subject teachers, which led to too many classes per teacher. The need to allow these classes to do practical work was also seen as a problem as there were no qualified helpers to prepare the experiments. The '*lab technician has left on promotion' (*Malane interview, pg 5) she observed. The teachers thought that one of the requirements of the new curriculum was to teach the single and double science just as they would the triple science students.

> …the main difference is the paper 4, which has been introduced to single and double, which is more like a practical… So it means to this students you can't always just…teach without like doing more of experiments or demonstrations (Malane interview, pg 3)

Teachers viewed the demands as too much for them due to the teaching load and lack of support within the school.

Teachers' Perception about Learners

Different views from teachers about the learners at Domboshaba SSS had been discussed above such as concerning discipline, their motivation to study, and forms of

support for them to study will be discussed. Teachers perceived learners to be generally undisciplined and hence not motivated to study. In contrast triple science students were cited as very motivated. Ms Malane gave an example of subject selection as one of the main sources of discouragement for the single and double streams. She said:

> …the separate (triple) science group, those you find that they are sort of highly motivated. They are sort of responsible, because they know what they have to do… (Malane interview, pg 15)

Students taking single and double science subjects tended to feel destined for failure. The teacher expanded on the students taking single sciences:

> … It's like the fact that it was like said you are going to do single science…. the whole thing de-motivates them. They have already given up… and if you tell them that it is possible for you to get 'A' in single science, they don't even believe… (Malane interview, pg 15)

Learners had various support structures for learning in Domboshaba SSS, for instance science clubs and afternoon studies. Saturday studies had been cancelled due to what the teachers saw as lack of desire by most learners to devote more time to school work. It only had partial impact. This had limited learners' support to study. Mr Kgabo thought learners resist learning to an extent that when:

> …you have given them an assignment, the way they answer. You can clearly see they didn't give it enough thought… they basically copy from other students so … they are not well motivated (Kgabo interview, pg 10)

Other structures to support students learning such as science clubs had had limited impact too due to lack of support by teachers. Mrs Malane said,

> Some are motivated especially those who where in clubs in junior secondary schools, which were excelling. They come here with the hope of getting into the same clubs and continuing, but due to the fact that as, teachers, we are no longer very supportive in these clubs (Malane interview, pg 15).

Limited support from teachers meant that learners eventually lost interest. Teachers in this school did not think that language issues were a big discouragement to learning. Ms Malane said about communication in class '*the language is okay, we don't have any problems'* (Malane interview, pg 14).

5.1.3 Summary of Domboshaba SSS

Domboshaba SSS was one of the newer senior secondary schools in the country, which started operating in the early 90s. As a new school, it had all round good facilities such as good classrooms and laboratories. Science facilities were facing challenges such as use of laboratories as base-rooms. Use of laboratories as base rooms was a result of shortage of classrooms due to expansion of the form 4 and 5 intakes. It had also led to a compromise in security and safety issues in science laboratories. This had resulted in vandalism to some extent. It led to restricted use of laboratories for science teaching and learning purposes such as in storing and displaying items in the laboratories such as posters. Teachers view the limited use of laboratories as restricting full utilisation for science teaching as nothing can be displayed for learners' viewing.

The following points seem to sum up issues that are prominent here

- Resources though not a serious problem, teachers felt it hindered their work
- The administration was generally viewed negatively due to the perception that they were
    - Poor administrators
    - Sided with learners
    - Poor collegiality and consultations with teachers
- Reaction to management mixed in the sense that teachers as a department wanted to do more for learners through setting up a disciplinary committee to bring learners to order
- Disciplinary committee was a sign of a department closely knitted and working together to try to work out teaching complexities together especially external factors affecting teaching and learning. They blamed all the ills of the school to lack discipline which also disrupted progressive teaching in the school. Frequent changes in administration were seen as the root cause of all problems.
- It was an innovative department which wanted to be proactive, but its work was always curtailed by the administration for fear of mutiny.

5.2 TAGALA SENIOR SECONDARY SCHOOL

5.2.1 A Portrait of the School from my Observations

General Description of School

Tagala SSS is located in a small village called Tagala. The village is surrounded by hills, resulting in the school being sandwiched between two big rocks. Students at this school come from mainly the surrounding smaller villages. And because of its close proximity to urbanised settlements, who draw on the same student pool take all the best students leaving only average performers for Tagala SSS. Teachers wondered whether they were expected to do miracles moulding 'A' grades out of low grade material. It is a school renowned for a history of great academic performance, but that history seemed to be fading. The school had been doing consistently poorly at the time of the study. Those familiar with its history were not amused, including parents who took their children to this school specifically to remove them from the town pressures and also to alleviate accommodation and transport problems. It is one of the few schools in the country which still has boarding facilities.

The Physical Resources

The main claim to fame for the Tagala SSS was its continuous excellence in sports activities. Some people spoke disparagingly of '*the sports academy*', due to the facilities and the amount of time and money devoted to sports. This was the only school I had been to in the country that had all-round, well-developed sports facilities. The basket, tennis, netball courts were covered in tarmac and even the soccer field was well kept.

The school had a lot of buildings, and most were used as student base rooms. There was a mix of very old building structures and a new chain of blocks that brought a modern appearance to the school. Most of the classrooms were old, all painted sky-blue. The old buildings also included the old staffroom and administration blocks then used as the school health clinic. The clinic was very neat and well kept. Other old blocks appeared damaged, students desks and the interior fixtures like ceilings, notice boards, sockets, floors, appeared old or vandalised, though some classrooms seemed recently renovated. The dining hall also looked very old and dilapidated, the doors

damaged, but the interior looked clean and well kept. This included the long tables used by students for their meals.

All the newly built blocks, which were mainly double storey blocks, were still in good condition. This included the science department, home economics, computer science, one block of four classrooms, and the new general purpose hall. The science laboratories were not in very good condition inside, cabinets and some of the sockets were broken. There was anecdotal evidence from teachers that the Chinese building construction company responsible for the new buildings had used low quality materials, which broke easily.

The new double storey classrooms looked unkempt inside, though neat from outside. The outside, like a few other blocks possessed some murals depicting the community habitat. The wall paintings showed wild animals, a family pounding grain using a traditional mortar and pestle. These pictures were painted by an art student some few years before. The multi-purpose hall had different pictures, depicting Christian scenes like the 'parable of the sower' from the bible. These reflect the school motto or themes of excellence, with the message that hard work pays and that you reap what you sow.

The School Administration

The motto has a strong relation to the school's connection with Catholicism. As a formerly Catholic mission school, it generally has a chaplain as one of the school administrators and so conducts church services in the multi purpose hall every Sunday, compulsory to boarding students. All the administrators including the chaplain and HoDs' offices were housed within the new administration block. This was also where the maths and science HOD was based. The block was very distant from the science department. There was a general feeling by the science teachers that the HOD was too distant who as a mathematician, was far removed from issues surrounding science teaching.

The Science Department

The three science sections were all located in two two-storey blocks of eight laboratories, four on each floor. The physics laboratory also used two of the renovated

laboratories from the old science block. There were two preparation rooms on each floor, but those on the upper floor were preferred.

Settling In the Department

Like all science senior teachers in the country the senior science teacher was attending a one week professional development workshop in Gaborone during the week I arrived. The chemistry coordinator, Mr Mano, a new teacher, helped me find chemistry teachers to work with. Mr Mano readily agreed to be part of the research team. One of the first chemistry teachers I met was the most experienced chemistry teacher, Mr Metsi. He has been in the field since about 1999. I first met him attending a workshop in 2003 at the UB. He was very quick to decline participating, citing too many school tasks such as analysing and compiling the previous BGCSE results. He did not want any more commitments, he said. Finding the other three teachers took some time as they were not situated in one place. They are many science workrooms and so teachers could be in any of these.

Mr Mokone, one of the youngest chemistry teachers, agreed to be part of the study. Including the only available female teacher Ms Dikabo into the research study became a problem. I had initially thought, because I knew her this would make it easy to have her in the team. She declined in a simple, cheerful manner. These made me think she was only teasing, which made me pursue her further a couple of times. She still declined, but now appeared cynical about my intentions and so I had to withdraw. As it appeared later, she was one of the pitiless teachers when it came to beating students. She did invite me to her class at times. On one occasion, students were discussing the concept '*diffusion*'. Ms Dikabo stayed in the workroom till they had finished, she said she wanted to help them become more open and involved in the discussion. Some days, when students made noise, the cracking sound of a whip would be heard coming from her class. Most of her lessons were held in the laboratory adjacent to the main workroom. Other teachers were not happy with her beating learners, but none of them spoke openly about it.

Resources of the Chemistry Section

The three science sections were all located in two two-storey blocks of eight laboratories, four on each floor. The physics laboratory also used two of the renovated

laboratories from the old science block. There were two preparation rooms on each floor, but the upper floors were preferred.

Figure 5.4: An uninhabited workroom at Tagala SSS

The lower workrooms together with most storerooms were flooded with biology (body) models, or newly arrived equipment like apparatus, chemicals and ovens. Until I left, they had not been moved and stored properly. Though there were two laboratory attendants, who were mainly used by the biology teachers, they seemed not to care much about order in workrooms and storerooms. Apparatus for chemistry, physics and biology could be found mixed in almost every room. The new apparatus were still unpacked, wrapped in plastic wrappers and not stored properly (see fig. 5.4 above). For instance, there were many biology models and many microscopes, still in their boxes, some still to be assembled. It also appeared as if there was more new biology material than for the other sciences.

The department appeared to have many resources, but a lot of the items seemed misplaced. Some teachers even wonder if some of the apparatus had been intended for this school. All the chemistry laboratories were the same and had standard facilities like fume hoods, gas and water taps and power sockets on benches. They were in good condition except for cabinet doors and power sockets that were broken. The chemistry storeroom was in good order, with proper labels for all the available chemicals. The unoccupied workroom housed a lot of items that had arrived after the completion of the laboratories, for instance some chemicals and biology models which don't seem to be of any use. Mr Mano said about some of the items/boxes,

> They are just brought in by the government as a batch …I do know if it could be useful to look at those boxes up there... You never know what was inside… Some of the things [are] things that are already here, that we don't need. For example retort stands, there are more than enough but some of the things are not there… (Mano interview pg 4)

It was also common in the department to find apparatus and chemicals which had been used in experiments left in trolleys, trays or boxes for ages. The laboratory assistants hardly ever put material back in their original places. This created disorder in some storerooms and workrooms.

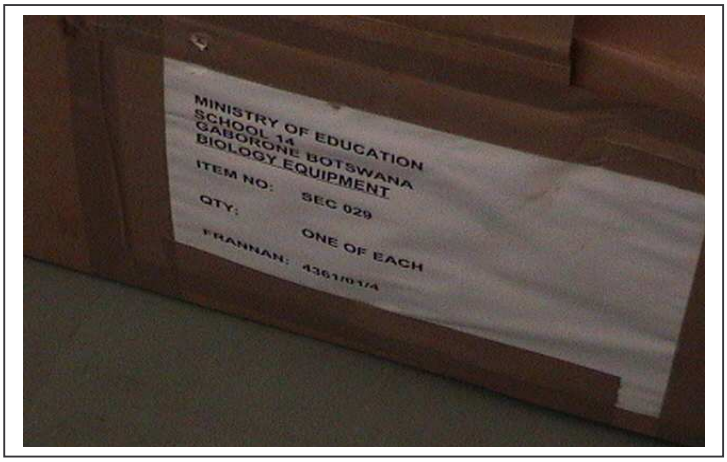


Figure 5.5: One of the many unopened boxes at Tagala SSS science laboratories

Figures 5.4 and 5.5 shows some of the newly delivered items like biology models and chemicals in the ground flow preparation room. The teacher was not sure that they were all destined for this school. The pictures above also show the lack of care in the department with regard to storage of valuable assets like newly arrived materials (stock solutions and chemicals) which were left scattered all over the general purpose rooms.

5.2.2 A Portrait of the School from the Perspective of the Teachers

The chemistry section has standard items as shown in table 5.1. The pictures above attempted to support some of the observation made on ground. Teachers' perception about the resources will now be discussed. Data from interview analysis was used from the two teachers. Teachers gave their opinion about the availability of resources in the department. They also gave their views about how the school and department functioned to support teaching and learning.

Science/Chemistry Resources

Teachers generally considered the department to have adequate resources for teaching chemistry. In spite of this, there were certain areas where teachers thought they were over-resourced or lacking. For instance Mr Mano said about his experiences when teaching electrolysis:

> …we don't have these electrodes …were you can collect the gases, electrolyse sulphuric acid and then you have to collect the gas and then make a chamber for testing… that particular gas… (Mano interview, pg 4)

The teachers I worked with thought that the hindrances in terms of resources were minor. They identified their major challenges as new teachers as coming from settling into teaching, especially being part of the team in their department.

School Ecology and Management

Mr Mano and Mr Mokone felt there was so little integration between chemistry teachers that it is not easy to know what the objectives of the department were. The youngest teacher Mr Mokone felt the department in general was not very welcoming.

> There was no formal orientation, that is like this is how we do things in the department like say for chemistry, how we do things in chemistry, how we arrange things like scheming, those things we haven't even done that, and for a new teacher like me, it's a difficult thing…I was just given a syllabus and that was the end (Mokone interview pg 4)

Further signs of a disjointed section were reiterated by Mr Mano who had been in the school a year longer than Mr Mokone. He was coerced to coordinate the chemistry section and seemed to face some problems leading the section due to the older and more experienced teachers' withdrawal from being part of a functioning and grooming community. He emotionally said this about the way his more experienced colleagues belittled new teachers:

> The only problem that I have it's personal now, that you know as a new teacher I think we should be given the necessary respect and the necessary mission that you are a teacher yourself too. You joined them to be part of the team not be a minor of the team and be … treated as a teacher too because you are a teacher too (Mano interview pg 4)

The young teachers were unhappy with the older teachers who they claimed did not treat them like equals or they tried to stifle them through lack of support. Science teachers in the workroom seemed to relate well, chatting and exchanging information,

but sharing of the work place with teachers from all the three sciences masks the frustrations they were going through. It was harder for them to be nurtured by their peers on issues relating specifically to chemistry teaching. The two new teachers said that they had been left to fend for themselves at that early stage of their careers. Mr Mano told me about how uncooperative the older teachers Mr Metsi and Ms Dikabo were. Mr Metsi stayed withdrawn and isolated from the rest of the teachers as he had found a tiny spare office on the ground floor. He was described by his young peers as very selfish and insensitive. Mr Mano said about the chemistry section:

> …we always meet different people with different attitudes… One of you would know that there is only one bottle of calcium oxide and it would have to be shared between seven classes, its only one…instead of just saying let the one who is going to be the first do it…somebody will take it and hide it… (Mano interview pg 6)

The two young and inexperienced teachers thought it was not only shortages of material that lead to such behaviour, but that there was a lack of desire to share information that pulled the chemistry teaching down. Mr Mokone said this about one of his older chemistry colleagues:

> There are situations whereby some teachers nearly fought because somebody… used his handouts… That that is my information…I think they must be sharing how someone is running his class… I don't think that should be a secret…they hide, they don't want us to come across their handouts. If they happen to see you using them, it's a big problem. It's more like people in competition that I am using these things and they are good for my students… (Mokone interview pg 11)

Some teachers also tried to pull them down and reduce their enthusiasm to work in many ways. Mr Mano said about some negative attitudes coming from the department:

> And you know no teacher should…look down on another teacher or think that he is trying to be smart by doing some (work)…I am saying this because at one point I would give test scripts back the next day after writing, so other students would demand (scripts) from their (chemistry) teachers after a duration similar to mine. And it became a problem to (teachers), to say… you are trying to look smart to (students), I am not trying to look smart, it's only that I can…If you can't you can't (Mano interview pg 11)

The inexperienced teachers felt that the disjointed nature of the chemistry section and the science department in general was a sign of weak leadership within science. They thought that there was no one to provide guidance on how the department should run.

'*There was no formal orientation that is… this is how we do things in the department like say for chemistry' (*Mokone interview pg 4*)*, he observed. Things like lack of order easily lead to lack of control over situations. Mr Mokone described the senior science teacher's lack of leadership qualities:

> the senior teacher, who is supposed to give mandatory words or duties to (rightful) people… that this year we want to submit a full format of how we are going to operate, in terms of full schemes, scheme of work, well categorised in terms of time, arrangement of topics, what we will be doing as a team not as individuals… (Mokone interview, pg 4)

Failure to work together in this regard had led to teachers teaching at their own pace and teaching topics of choice, which had led to covering different topics in different classes. Concerning the two laboratory assistants, who he said were reluctant to work when given tasks:

> We never know whether they are for cleaning labs, or for working as assistants in terms of when we are doing experiments they are supposed to be there you see. Because when we were complaining that labs are not cared for, (that) no one is reporting damages …when they are dirty, no one is taking care. The senior teacher is not even sure really who is responsible for that, you see. The only thing she could say is that we need…more staff to do those things… (Mokone interview pg 4)

Mr Mokone did not agree with this as he thought what was needed in the department was not more personnel but '*we just need organisation'* (Mokone interview pg 5).

Support by the Management

The science senior teacher and HoD were blamed by teachers for some of the laxity in the department. The teachers thought that the senior teacher was happy with individual teachers just teaching. She was said to have failed to stamp her authority on the department. Science teachers also blamed the lack of order on the department to the head of department's failure to visit the science section. Mr Mano said about him:

> …if the HOD was involved fully in our day-to-day running of the department, I think he would have a better picture of who to say is doing the work properly and so on (Mano interview pg 10)

The teachers thought the lack of his presence made him know little about their needs, especially issues concerning their day-to-day requirements and even long term plans for the department. Mr Mano thought that:

> The school is supposed to organise internal workshops like for the assessment workshops are supposed to be organised, initiated by the department, that we have this number of teachers, we want them to go and be equipped … like on the new systems like practical skills… I think it can be initiated by the department, hand-in-hand with the HOD…So far there is nothing. There is no input actually from the head (HoD) (Mano interview pg 12)

Management Change

The school was going to lose its principal and its deputy to Domboshaba SSS. Teachers were all excited about these developments. Since they believed the principal had no leadership vision as evidenced by the continued decline in discipline and performance since he joined the school. The last time the school had achieved good results was when he had just taken over. At that point, he had only helped to maintain good BGCSE results to obtain second position nationally. From then on the best they position they had achieved was 10th position. There was strong link perceived to be between the principal and the examination results as was the case in Domboshaba SSS.

Tagala SSS was currently ranked 20th out of the 27 government schools. The decline in performance was attributed by teachers to the principal having softened learner discipline. The soft attitude was believed to have sowed seeds of laxity within the teaching force and even worse with the learners who did not want to be rebuked or disciplined by teachers in class. Any clash with teachers led to students reporting to the principal who would in turn request the teacher to apologise. Teachers thought the principal was biased in favour of the learners and it was:

> …a destructive relationship …If you discipline a child, he takes you …and then you are made to look as if you are bad. Obviously you will pull back…and that pulling back…kills students (Mano interview pg 12)

Teachers felt that being summoned by the principal and having to apologise to a student was degrading their status. Most teachers had adopted collective punishment, remaining silent about learners' behaviour allowing them to plummet on their own.

Unwanted Programmes

Some teachers also blamed the school for being too receptive of too many piloted projects from the MoE. The government was then trialling a number of innovations in the school like a new way of assessing course work and offering a new subject

(music). Teachers thought extending the intake had lead to expanding the school population, thus allowing access to under-prepared students.

Teacher' Perception about Learners

Learners' support system also came from teachers linking that to the functionality of the school and teaching and learning in general. As a boarding school there are many areas learners receive support from the school such as feeding, accommodation and extended studies.

Tagala SSS was very active in sports, as Mr Mano had described their excellence in sports.

> …like I said this is a sporting school… Students want to keep that record, and then with the ample resources that are given, they have got …soccer boots, tennis… if you look at the national finals … we sometimes send 7/9 (teams), last year I think it was 9, while other schools can only send one… (Mano interview pg 12/13)

There was a feeling that attempting to keep high sport standards had led to the school spending more than it could afford. This also meant using money allocated for other needs such as food, where it has been noticed that the quantity and quality of food had gone down. Students felt they were not only very lightly fed, but also receiving monotonous meals like eating pap and cabbage for lunch daily. Chicken and beef or other preferred meals were no longer part of the menu. Teachers thought that

> right now the menu for this year has being reduced, and they are always complaining, (about) food and those who are really feeling the pain are the form fives, because last year things were better, now its worse (Mokone interview pg 11)

Most of the students could be seen during breakfast and lunch going to the main entrance to buy food from the external kiosks. They bought various food items of choice such as fat-cakes and other filling meals. Some students claimed to no longer be eating at the dining hall at all. I spoke to one boy who had been initially admitted to a school in the city, but whose parents had felt would be better off in this school. The boy regretted having taken the step, but did not realise that things had been different in the past. The form five students had a clearer picture, they said meals used to be of good quality.

Teachers thought also the school went too far in maintaining its historic name by sending choirs, traditional dance groups to far places Ethiopia and the US as had happened the previous year. Teachers also thought status achieved by the school in having two new school buses had diminished the limited school budget which was not healthy for the school's main goals of teaching and learning.

Learning and Accommodation Support

The boarding facilities were also called into question by Mr Mokone. He referred to the water situation in the school, especially in the hostels:

> Currently the environment …is poor…the students carry (fetch) water for themselves from school taps, there is no water in the hotels, and hostels are just in a mess…in the mornings they wake up early in the mornings to go and fetch water to wash. At lunch they run to the hostels to go and fetch water... and when they come (from study) then they take it and wash. I think that's not a supportive environment really (Mokone interview pg 11)

The daily activities were structured such that learners devote a lot of their time to studies. For instance, every day learners had two study sessions. Learners were also requested to present speeches at assembly about life in general, employment opportunities, and issues relating to how to stay focused to pass the BGCSE. Most teachers attended, especially those on duty. They too made speeches encouraging learners to work hard. Mr Mokone thought that where teachers and learners do not attend, little is done about it.

Science was considered one of the least recognised subjects in the school compared to sports and other clubs. Learners had little support in terms of enriching academic structures like the science club. Mr Mokone felt the senior teacher was responsible for the failure of the clubs due to lack of interest. When she had been approached by learners wanting to pursue their projects from junior secondary, she could only say the club would be started in the coming term. Mr Mokone said,

> But the students are curious, about two have asked me [about] the science club, some of them told me that they want to continue with the projects they did at junior level. So I asked my senior and she told me no, maybe next term, that's when it would start but we are not sure because teachers are not interested (Mokone interview pg 10)

Lack of support was not only seen as lack of personal support from the department and senior teachers but the school was perceived to be spending too little money on financing science related work. Mr Mano said:

> For example, look at the maths and science-fair, this is one activity where the school could be able to put some cash you know. Let the students buy some of the things they want to use for projects…Like in the last science-fair, not even a single thebe (penny) was given to us by the school. Obviously if a student wants to do an electronic project it's not going to work because he has got to buy [components] (Mano interview pg 12)

As a boarding school, the teachers thought they could do more as they had plenty of time with students to organise extra lessons, '*…I think teachers don't mind (working) the whole day' (*Mokone interview pg 3*).* The two teachers said they had no problem organising afternoon lessons or evening lessons to give practical sessions or with running the science club as Mr Mokone said:

> Currently for me I will say, I am lucky that I am working in a boarding school... To come for evenings and we do our practicals in the evenings. I have done that before with 5x, and that is what I will continue doing from next week onwards (Mokone interview pg 3)

Student Discipline

Though most learners live in harmony, teachers thought there was a practice of ill-treatment of learners in the lower classes. A number of learners at Tagala SSS had been suspended for bullying form four learners. Victims suffered abuse such as pouring water on them or their blankets or being forced by other learners to do their laundry. Those involved in minor offences could be seen time and again clearing the grass on the school compound. The teachers doubted the weight and effectiveness of this punishment as it did not seem to curb the problem.

Teachers thought that there were learners who were generally considered less interested in learning and therefore prone to creating disciplinary problems and Mr Mokone felt it was mainly the single science learners who fell into this category. Teaching three single and two double science classes had made him see a pattern of problematic behaviour. He said about one of his single science classes:

> Currently they have suspended so far four and currently three has come…there is a serious problem in 5y (Mokone interview, pg 11).

Motivation to Learn

Mr Mokone thought that those classes with ill disciplined learners have difficulties learning. The students also did not seem to know what to do about their lack of drive to learn. When asking the class what he should do to help them, he hoped to get some suggestions about which approach they preferred:

> I was shocked when they said, 'no just beat us'… but you have failed and I don't know whether you don't know… the concepts, or you haven't done this… they said 'just beat us'… Generally from what I have heard, and from what I have seen when on teaching practice, single (science) students' curiosity is low (Mokone interview pg 13)

Mr Mokone was of the view that the lack of motivation to learn could be traced to the selection and admission process for senior secondary school:

> … normally in all schools after selection of form fours, they like to take they call them 'sports students' even though they have failed… so I just suspect that maybe this is a class where after form four selection was made, they went around the country to look for these ones…Every headmaster, every sports master wants runners, wants those who are the best sports students. Because the class if full of sports students, there are times when half of them are almost out of class, only to find that no, they went for a (sports) trip… and during the (internal sport) competitions I saw a lot of them being the ones in the lead. That's why I suspect that, ok these are the bunch of students who were just collected after the selection and were placed in 5z and the performance can really tell. This is the only class where there is no note writing, some of them don't have notes at all (Mokone interview pg 13)

Other learners were thought to be well motivated to study for instance the triple science learners.

> If you tell a pure science student that he will destroy his school chances, you will see him trembling. If you tell him man I am taking you to the yellow file, the file of defaulters… you will see him tremble. Single science students don't care (Mokone interview 13)

The teacher stated that with motivated learners even empty threats are enough to get them focused to their academic work. The school had come up with some ideas to try and motivate learners to learn. Learners had been encouraged to form study groups that were supposed to meet during weekends. This had faced challenges as learners had received no guidance on the composition of the groups. Learners consequently had divided themselves along academic lines of single, double and triple sciences.

In this school, there was a belief that the triple science learners were superior to the double or single science learners. This had led to learners not feeling comfortable mixing with those from different science streams. The single science learners preferred to struggle together rather than to seek help from a triple science learner who would make fun of them about having been asked trivial questions. The study groups had been formed following a call by the principal to try them as a means of improving the school's performance, but it seemed the lack of monitoring in setting up the groups had been counterproductive limiting the kind of communal learning that was envisaged.

Language problems were also cited by the teachers as a great challenge faced by majority of learners. The two teachers thought that overcoming this barrier had been problematic. They were left with little choice but to mix languages during teaching. Mr Mano said '*obviously as a teacher somehow you will have to switch between the two…'* (Mano interview pg 12). Mr Mokone called this '*…to Tswana-lise…so sort of Tswana-lising it and using some more familiar examples'* (Mokone interview pg 2) in vernacular.

5.2.3 Summary of Tagala SSS

Tagala SSS is one of the oldest senior secondary schools in the country. Having recently been revamped, especially the practical subject departments, the science department boosts of eight new laboratories. The old fleet of classrooms also had helped to ease classroom shortages hence, in this school none of the science laboratories are used to house students for purposes other than science activities. Hence, all laboratories are generally in good conditions.

The teachers perceived the department as having a shortage of apparatus and chemicals for running some experiments. But teachers mentioned trivial apparatus such electrodes designed to collect gases, which only formed a small component of practical work that could be carried out in the BGCSE curriculum.

The young chemistry teachers seemed to struggle to fit well with the department's culture especially due to what they cited as lack of support from the more experienced teachers. The chemistry section had a very young teaching force with four of the six

teachers' experience ranging from 6 months to just 18 months. It was coordinated by one of the inexperienced teachers taking part in the study. He seemed to face challenges in uniting the section, as well as keeping up with the teaching demands.

Moves of indifference towards the less-experienced teachers included the tendency by some teachers to hide certain chemicals sparing those for use with their classes. One such move included the failure to want to share teaching materials such as books and hand-outs. Thus, instead of the more experienced teachers trying to help the inexperienced ones to settle, they were harming and even hurting their development. This left the less experienced teachers frustrated, which reflected badly in their organisational skills such as organising the chemistry section and preparing for lessons.

They were not surprised that the school has been doing very poorly lately like for the past two years in a row. The lack of cooperation was seen as a result of weak leadership in the department and the school in general, which spiralled even to ancillary staff. The storerooms and preparation rooms were hardly ever cleared of used or new apparatus. The young teachers felt that the laxity in the school management was ruining both students' desire to learn and the teachers to maintain professionalism about their work.

5.3 MARU SENIOR SECONDARY SCHOOL

5.3.1 A Portrait of the School from my Observations

General Description of the School

The school is located in Maru, a sparsely populated village. More than half of the population of the village are largely dependent on subsistence crop and livestock farming, but Maru SSS boasted of boarding facilities, sports and academic excellence. Having been to school there myself, on entering the school I expected to see the school of old, but there seemed to be a significant change in the landscape of the school, starting right from the school gate. The wide fence double-gate had been replaced by a sliding gate and the entrance was decorated with brown stock-bricks. The name and school mission were written in bold by the entrance. There was a small

security office by the entrance, and the officers could be seen inside in khaki uniforms. Their duty was mainly to keep boarding students inside the school especially during teaching or school time.

Figure 5.6: Learners inside school standing by the main entrance

Maru SSS is totally shaded by a huge Mopane forest and there seemed to be no disadvantage in terms of infrastructure. An inner-circle walkway connecting all major areas like the teachers' quarters, the boys and girls hostels was completely paved. There was also a network of corridors linking the classrooms. Most of the buildings looked new. All the old classrooms had been renovated and painted, the interiors given new notice boards, chalkboards and/or white boards. There were also a lot of storage facilities for students. Metallic lockers had been mounted on the walls of almost all the classrooms, a good number of which had been vandalised. When I attended school there used to be an empty space which was filled with a large new multipurpose hall and the dining hall. There were also some new double-storey blocks, the design and technology and home economics and fashion and fabrics blocks and the physics sub-department. More classrooms had been built as well, about five single-story blocks of classrooms that ran in pairs. Altogether there were about 40 classrooms used as base rooms, as well as two caravans used as base rooms for classes for which a classroom was not available.

The Science Department

The chemistry section like in other schools fell under the 'Mathematics and Science Department'. The science section was the largest sub-department in the school,

comprising sub-departments like mathematics, computer studies, and the three sciences. There were nineteen teachers in the science sub-department alone (six biology, six physics and seven chemistry teachers). The science laboratories were clustered close together and this was an envied sub-department in the school as it seemed to be well-organised and attaining good results every year. The staff tea-club enhanced the unity. Every morning between 10h00 and 10h30, the teachers would gather in a preparation room converted kitchen to have a large morning meal ranging from fat-cakes (vetkoek), beef stew, serobe (tripe), and various hot and cold beverages. Teachers liked to be here as there was a lot of talk about various issues like soccer both national, international or the teachers' football team. Science teachers occasionally held informal short meetings here during tea.

Figure 5.7: Tea time at Maru SSS science department

Settling into the department for me also involved finding a space in the chemistry preparation area and joining the tea club which were both smooth. Settling was easy because I already knew some teachers in the science department.

Characteristics of the Chemistry Section

In the late eighties, the chemistry block used to be two simple classrooms with movable tables and no cabinets for storage. As a former student in this school, I know that students did not like these laboratories as they were less interesting than the other two biology blocks that kept lots of posters, specimen of preserved reptiles, various bones of different animals. The old block had at the time of the study been renovated and turned into chemistry specific laboratories. The preparation space between the

two labs also housed six chemistry teachers. Teachers had placed small tables at the centre of the room, on each side of the central veranda so as to all fit in.

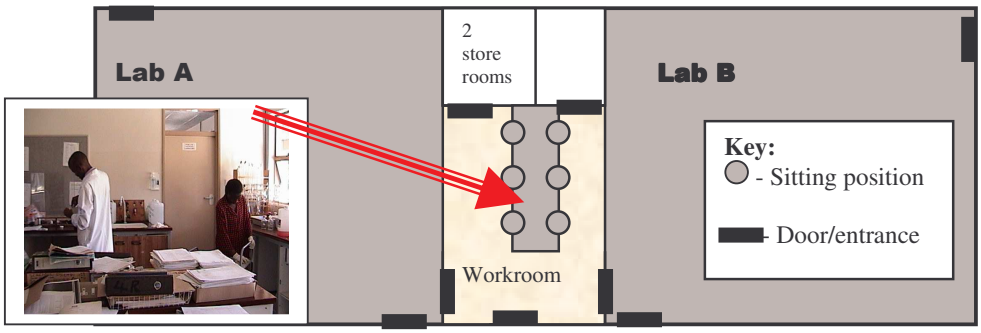


Figure 5.8: Layout of the renovated chemistry laboratories

There was always some paper on tables, question papers or students' scripts to be marked or exercise books, but all were stacked in an orderly fashion. The layout described above can be seen in figure 5.8. A photograph inset provides a general sense of the setting.

Figure 5.9: The renovated chemistry laboratory at Maru SSS

Four new laboratories have been added one of which was chemistry specific. Thus altogether there were three chemistry laboratories. A summary of the school facilities, especially related to science teaching are given in the table 5.1.

Table 5.1 showed that Maru SSS has many resources that seemed adequate to support teaching chemistry. Altogether there were 10 laboratories in the science department. Each of the science subjects was allocated 3 laboratories. The remaining one was for general purpose use, used by the three subjects. This was the only laboratory that was

not well resourced like the other subject specific laboratories. For instance, though it has permanently fixed tables (workstations), they were not mounted with wash, power and gas points like it was in the other nine. All the added features in the nine labs were working and in good conditions. The basic apparatus like retort-stands, glassware and chemicals are kept in these labs. This includes commercial made posters in all the laboratories (see fig. 5.9 between windows).

As previously explained, the school setting has been taken in this thesis to include teachers' perceptions of school facilities, the school's ecology and management concerns. The teachers I worked with, Mr Bose, Mr Mpho and Mr Sunny talked a lot about school facilities, citing lack of equipment, materials as the reason for not doing activity-based learning. There were also some references on other inhibiting factors related to the school's ecology and management system. These factors were discussed under different headings below.

5.3.2 A Portrait of the School from the Perspectives of the Teachers

Science Resources

According to teachers, they thought they had enough laboratories, but this did not mean that there were no problems with venues. Teachers thought shortages became more apparent when considering the population of the school. Mr Bose felt that some lessons were being held in classrooms for teaching instead of laboratories, which limits opportunities to give practical work. The situation could be worse for those teachers allocated mainly the single and double science streams as they are given less priority to use laboratories.

Shortage of apparatus was perceived a great challenge by some teachers. The school had no funds to buy any of the apparatus they requested. The teachers thought the administration was not very supportive in this regard as all their requests were rejected on the basis of unavailability of money. This led to too much improvisation. Mr Sunny did not think it was good for attaining the quality teaching they were encouraged to deliver. He said that crowding was a problem as classes were too big,

> Even the lab itself is not able to accommodate students actually experimenting…the workstations won't be enough… (Sunny interview pg 6)

Teachers generally thought the school did not care much about teachers' views.

School Ecology and Management

Maru SSS had been dysfunctional in the past few years in Mr Mpho's opinion,

> …teachers missing lessons, going to town (about 80km) at times during working hours during month end… even the head (principal) would…(Mpho interview pg 14)

The coming of the current principal brought order to the school, the school had started to function well, and students' performance had improved. But the advent of a new principal meant introducing a new leadership style which meant that some teachers thought they no longer played any active role in making decisions.

> They are running the school as a one-man show, so even when you make comments during the meetings… nothing comes out of that even when they seem to carry weight (Mpho interview pg 11)

This had made teachers feel abandoned and unrecognised, with the lack of recognition increasing stress. Teachers got angry when they are not consulted. As Mr Mpho said, *'I think you know, there seem to be more anger here, people seem to be more angry* …Mpho interview pg 12)'

Mr Mpho viewed the administration, especially the principal as very unsupportive of teachers especially science teachers.

> She is failing to come to our department [and] to our meetings. We are not that much close… (Mpho interview pg 13*)*.

The result had been lack of understanding of issues surrounding the running of the department. For example, access to the laboratory had been restricted, making it difficult for teachers to work after hours or during weekends. In the past, keys could be obtained from the security office, but having the science senior teacher keep the keys had caused a lot of problems. The administration did not want to reverse this control, looking at security issues rather than trying to understand the work ethic of the science teachers.

Another consequence of lack of understanding of issues surrounding the science teaching was cited as interference by the principal in the number of tests and homework to be given. Mr Sunny felt that the demand to give more work has unsettled many teachers as they saw this as a sign of invading their autonomy in doing their work. He felt that the chemistry staff was sufficiently familiar with departmental, curriculum and learners' needs to make better decisions than those dictated by the school administration. If there were too many assignments this could easily lead to students '*just copying from each other to submit, (*Sunny interview pg11) without much learning taking place.

It was also this difference in philosophy that made the principal know little about them and their needs. For example, a number of teachers in the school had applied for promotion to the level of senior teacher and HoD. Some teachers who applied had been acting in those positions, but none of them were appointed. The teachers believed it was due to the principal's obstructive character that younger and less experienced teachers from other schools had been coming in to fill the more senior positions.

> …there are about 6 - 7 new senior teachers in Maru. But there were some people who were qualifying here… like if you take the lady who is senior teacher in Setswana, she is a junior to the guy who has been acting as a senior teacher in Setswana…So how can you say … they support, where more than 9 posts are being taken by people coming from outside. And nobody from this school got any post! At least … one could have got a post somewhere, but if nobody could get then how can there be a support… (Mpho interview pg 12)

Another issue related to the first term internal examinations which teachers viewed as disruptive and unproductive.

> … they affect the syllabus … for example this term, first term examinations, I still feel it's a waste of time. Because if you look at the first term examinations, we haven't done much this term, so it's more like we are repeating last year's examinations…rather we could have used this time for teaching and have the second term examinations. But second term, especially with the form fours, everybody would have at least done more than three quarter of the syllabus and that would give people ample time to come up with very good questions for the examination, (Mpho interview pg 11)

Lack of involvement meant certain decisions were implemented without their approval. Teachers in Maru SSS wanted to make contributions, but whatever they said was never taken on board and they just had to follow instructions. They felt helpless

because there was no recognition of their views from the administration. Mr Mpho talked about reactions triggered by the decisions which always went against teachers. '*…I used to be very interested in teaching, but nowadays I think I am losing interest' (*Mpho interview pg 11). The teacher thought that it was things like the administration's lack of trust and collegiality with the teachers that made it hard to keep motivated in teaching and it got to a point where only minimum effort was put into teaching.

> …You work hard, you get nothing…So the best way is to be just on that level… if you try to put too much in teaching you don't get what you want, you get frustrated (Mpho interview pg 11)

There were further signs of withdrawal by teachers in the department that had previously been performing well. Mr Mpho stated that it was not just withdrawal, but some teachers felt like undermining the school so as to send their message of dissatisfaction across:

> Actually some people are not happy when Maru secondary came position 7, some were saying 'I wanted us to be number 20 something', because they wanted the school to drop, so that that effect could be seen … (Mpho interview pg 12)

In my view the plan to sabotage the administration did not reflect in teachers' work.

Support within the Chemistry Section

The chemistry sub-department had remained very cohesive despite the disagreement with the administration. The cohesion had been key to some of the successes the chemistry section had realised such as good results in the national league. The teachers spoke highly of their internal support structure. This dated back to earlier times when the now long serving teachers had been novices. At that time there had been 2 older teachers (both foreign), who had been very helpful in the structuring of lessons and encouraging peer collaboration.

Teachers still supported and worked together on issues relating to teaching. For example Mr Sunny, one of the new teachers was talking about his involvement in departmental preparation for practical examinations even though he did not teach a triple science class himself.

> Here we actually work together most of the time. Like now we are not even teaching any triple sciences but we always work together, help those who are teaching to get the materials (Sunny interview pg 6)

The same was true with preparing work schemes and notes that were then shared within the whole chemistry department.

> I think we are doing well together even for the notes, sometimes they prepare some notes and say this is the notes that I prepared… and we scheme together too (Sunny interview pg 6)

Support to Implement the New Curriculum

There was not much coming from the school authority to suggest they knew much of science issues in the new curriculum. The science senior teacher seemed to be the one applying some pressure for teachers to follow teaching that is supportive of hands-on laboratory activities. For instance Mr Sunny talked about demands coming from their senior teacher

> That's what we actually talk about most of the time in our meetings, they are saying for the science we should actually not be sort of lecturing… but doing the experiments… (Sunny interview pg 5)

There were also directives coming from in-service programs, which teachers were supposed to implement. Science teachers were officially authorised by the MoE to conduct lessons in ways exposing learners to hands and minds-on tasks. The weakness in sustaining lessons of this type lay in monitoring. This applied to professional development workshops organised to help teacher implement innovations. Chemistry teachers attended national in-service workshops during school holidays.

Relationships in Chemistry and Motivation of Teachers

There was a lot of interaction and cooperation between the teachers in the chemistry section. For instance, apparatus set for practicals was not for use only by one teacher, but available for other teachers to use with their classes. Teachers would either prepare the set ups or the lab technician would do it. Teachers talked about varied issues like marking schemes, and sometimes commented or complained about unfairness in the grading by other chemistry teachers. They also discussed questions set for internal month-end tests.

Mr Bose was always challenged for not phrasing questions well. They claimed his questioning style could mislead students. Sometimes discussion would take the form of an attack on a member who seemed to be very elusive, like Mr Mpho who it was said, had dodged school just to go and preach in the village. The same was said about Mr Bose who missed a lesson to go and supervise at the dining hall. This seemed a close relationship where teachers could question each others' commitment to teaching or lack thereof in a constructive way. Cohesiveness was still very high in the chemistry section, but there was a growing stress and low morale creeping in, which teachers attributed to bad service conditions, unattractive pay and the communication gap with the superiors. This seemed to have caught up with even the most experienced teachers in chemistry, who at that time seemed to have lost enthusiasm for teaching.

Another important area in this study was the way teachers perceived learners in this school.

Teacher' Perception about Learners

Teachers thought the school had good provision for learners to stay after school and study in comfort. Learner care ranged from accommodation, to feeding and provision of study areas. They also had a student representative to relay their disputes to school authorities. There were many enforced study sessions during the week, for instance evening and afternoon studies every day that ensured learners devoted most of their time to school work. Learners also had to attend Saturday morning and Sunday evening studies. As a boarding school, the authorities ensured in this way that learners devoted most of their time to academic work. Non-boarding learners did not have access to evening and weekend studies, hence they felt a bit disadvantaged since most did not have healthy study support in their homes. The high support for both academic and personal structures offered in school did not necessarily translate to high academic excellence due to issues such as learners' background and motivation.

Motivation to Learn

Learners' motivation to learn had improved significantly during this study following some unrest in the past. Teachers believed the motivation to learn had come mainly from good BGCSE results, now students tried their best to either match previous

records or do better. Referring to the time when the school had been doing badly, Mr Mpho said,

> I think we were almost losing it when we were not doing well… if you take two-three years ago, it wasn't that good…even the teachers at that time, they were not (motivated). There were a bit of disorder… (Mpho interview pg 14)

Motivational talks during assembly and lessons had helped. During assembly there were days when learners made presentations about positive life attitudes, and senior teachers embellished this as desirable and the right ingredients for doing well and having a good career. This was also where teachers and the principal gave students tips on how to conduct themselves to guard against bad behaviour or contacting HIV/AIDS virus. Though the level of commitment and interest to study in the school had increased, there were also some worrying trends especially concerning the lower classes (form 4) and mainly combined science learners who remained less focused on learning. It appeared they were not benefiting from the support structures that were in place.

Students still saw single and double sciences as the poor relation of the more established (elite) triple science. This had affected morale to learn, and even participation in science enriching activities like the science club and science clinics. Science clinics were designed to offer remedial assistance outside teaching times.

> …But the problem with the learners is that there is this stigmatisation. The triple science see themselves being superior to the double, the double see themselves being superior to the single sciences… in most cases you realise that the triple science they seem to be more-friendly amongst themselves… (Mpho interview pg 13)

Though learners taking triple science in the school viewed these science activities positively, it had had little impact with double and single science students.

> …That is what they even said one time. They were saying they couldn't come to the science clinic where there is a bunch of triple science and double science students. That is why we even divided the labs… (Mpho interview pg 13)

The teachers were nonetheless still confident that it would continue to improve as it became more embedded in all departments, but there was still a lot to do to find more innovative ways of engaging and assisting the learners.

One of the constraints to learning in this school was identified as the learners' communication barriers. Like Mr Mpho said about language:

> That one is a very serious problem… because the problem here is some students come here, not being that good in English and at the same time not being good in Setswana. So if they fail to understand something here in English if you could use Setswana most of them would not even get what you are saying… some of them they don't even know how to speak…they cant even speak Setswana correctly you see. So it becomes a very, very serious problem…If you read most of their essays from the English you realise that they are just interpreting (*the local Tswana dialect*) straight into English… (Mpho interview pg 14)

Language limitations meant that students struggled to understand and engage in any meaningful class discussions. This was worse with average to low performing students who were found in the double and single science streams.

5.3.3 Summary of Maru SSS

Maru SSS was of comparable science facilities to Tagala SSS especially those related with the teaching of chemistry. The department boosted of 10 laboratories of which 3 were allocated to each section. Chemistry teachers were generally happy with the resources. They cited major shortages of laboratories as resulted from the difficulty in timetabling all science classes. This had generally resulted in prioritising laboratory use mainly to the triple science students. Teachers also mentioned shortages of certain apparatus, such as '*fractional distillation column' (*Simon interview pg 5*)* by Mr Simon. Mentioning a peripheral apparatus seemed to show how well resourced the science department was, but the teacher merely used the example as a justification for not carrying out experiments.

The department seemed very well organised and run, unified by regular informal meetings especially at the tea club. Teachers in each section seemed even a lot closer to each other. The chemistry teachers even said they were closer to each other than the biology and physics teacher were. They attributed the closeness to having enhanced cooperation between teachers as they work. They claimed that excellent results for two years in a row, rewarded by a cake were testament to this. Working together meant teachers plan their work together, share experimental set-ups and consult each other more often.

The unity in the chemistry section and science department in general seem strong enough to neutralise what seemed to be negative effects cited by teachers as coming from the administration. Teachers contribute in various day-to-day running of the school such as taking in part in supervision at the hostels, dining hall during meal times, monitoring assembly and study attendances. The administration was cited by teachers as working in a top-down manner, which was seen as dampening the spirit of teachers. Teachers generally felt that their contributions in making decisions pertaining to the running of the school were not recognised. The school administration even made decisions affecting the running of the science department without consultations with them. Teachers were unhappy with such moves which they think had made them want to work against by school by pulling results down.

The data from the teachers show that the school's situation may influence the way teachers function, especially in respect of the implementation of the new chemistry curriculum. Their perception about the school ecology and management could be said to be negatively impacting on the way they carried out their daily teaching work. The same was true regarding facilities and lack of equipment and materials. The data also seemed to suggest that cohesion in the department tended to centralise curriculum decision making by bringing consensus. The decision making within the chemistry section has had the strongest impact on keeping teachers focused than the effects caused by impact from the administration.

5.4 LESEDI SENIOR SECONDARY SCHOOL

5.4.1 A Portrait of the School from my Observations

General Description of School

It was a goodbye Maru, hello Lesedi as I ended my third leg of the school visits. But there was no doubt that my trip to Maru had been a great success after positive feedback from the entire science department. I was in good spirits as I made my way into Lesedi SSS on Tuesday morning ready for the last 3 weeks of my stay here. In the morning the roads leading to the school looked very colourful as the majority of students walked to school. A chain of blue coloured uniform could be seen especially in the morning as they walked hurriedly alongside the road to the school. All students

came to school in uniform like in all government schools. Several teachers in the schools were on hand to greet me as I moved about in the school to meet the school authorities before consulting the department. I was already familiar with many teachers in the school, especially the science department. I have met some of the teachers during my University of Botswana study days, some during teachers' in-service workshops and my trips to school during pre-service school experience supervision.

Lesedi SSS is located in one of the large traditional villages in the country. Hundreds of small hills dot the landscape of the village, with some of these surrounding the school compound. Lesedi SSS had a new set of classrooms in the form of single storey apartment blocks set among old bungalows from the school's earliest days. The old blocks gave the appearance of an area that is neglected.

Figure 5.10: A classroom's exterior wall showing lack of renovation

In my early days of field work, the school appeared very old and shabby. Most of the classrooms appeared old and poorly planned and placed. These included the main staffroom block, administration block, maintenance block, the supplies centre and the dining hall, all built during its pioneer days. All these buildings were painted sky blue, but the internal and external painting was peeling off, revealing a cream white, paint also coming off. Also badly damaged were the ceilings in some classrooms, which also showed damage from rain seepage. The school claimed to have no money to carry out further renovations. It had recently undergone some face-lifting and the departments such as the computer, the science, the home economics, fashion and

fabrics, design and technology, art, and the library were all recently built. This seemed to have changed the landscape on one side of the school, making it more modern as all these double-storey blocks were built from burgundy coloured face bricks. It has aided in neutralising the poorly planned old blocks, made from short bricks and small but highly placed windows. The small and high windows make the classrooms poorly lit when the lights are off even during the day. All classrooms were connected by a blue-painted network of corridors, which had been extended to the new blocks.

On opposite ends of the school were two teachers' quarters. Most of the houses looked nice from a distance, on one side sitting over a flat hilltop, but there were a number of very old ones too, some of these were small round houses. Most of the teachers here shared accommodation, especially the new or unmarried teachers. This brings some misunderstanding between the housemates. The school had a large teaching force of about 100, thus making accommodation in short supply. Finding accommodation in the village like in the other three schools was never considered, as teachers were not willing to stay outside. The houses out of school were considered too expensive as they were not subsidised. With most teachers not willing to look for accommodation elsewhere, sharing became inevitable. Nobody was blaming the principal for all these ills. He was new to the school, having joined at the beginning of the year (2005). Though only three months in this school, he was very popular due to his jovial manner, his talks were always laced with jokes. The majority of teachers liked him for that, as they said he could talk to anyone. He would talk to visitors, security officers by the gate, and teachers in various departments. His presence was said to be felt everywhere, but mainly for chatting. It was only in the English department that he was not liked much because they claimed to dislike his bragging nature.

The Science Department Setting

The chemistry section had a large number of female teachers, three out of the six chemistry teachers. The senior teacher helped to select the teachers for my project. He came up with a list of the participants before he even consulted them. On being notified about their involvement, the three teachers complied. When I later inquired about their participation, they indicated that they were happy to be part of the research

team. The teachers were Ms Nakedi, Ms Bolaane and Mr Kopano. Ms Nakedi had been in the field a year before the conception of the chemistry curriculum in 1998. Ms Nakedi has been in the school much longer than the senior teacher whose longer teaching experience had been accumulated at junior secondary level. Ms Bolaane the other female participant had been teaching since mid-2002. Mr Kopano was the least experienced and only male research subject.

All science teachers spent most of their time within the science department, which comprised of two double storey blocks of eight laboratories. In between the two laboratories were a preparation room and two storerooms. The laboratory assistants spent most of their time in the chemistry preparation room. They rarely went to the teachers' workrooms also located within the department, but did chat with teachers when they were in the preparation room. There was a general feeling among teachers that the assistants were very uncooperative, as they don't want to accept requests from most of the teachers. Mr Kopano told me he did not bother looking for assistance from them any more.

All science teachers were housed in two relatively small workrooms, one on each floor. In the lower preparation room, there were two chemistry teachers, three physics teachers and also two weather-station workers. Each teacher had his/her own workstation, a table. There were 8 worktables in ground floor workroom, which is where I settled. I mixed well with all the occupants. The weathermen did not talk much, except to themselves or the laboratory assistants. When the weathermen were present, they were always busy with their work, filling up charts and tables with weather information from the mini-weather station in the school.

The upper-ground was occupied mainly by biology teachers, three of the chemistry teachers were also settled there. Though teachers, lab assistants and the weathermen were housed within the science premises, they appeared poorly integrated especially with the weathermen and laboratory assistants. Cohesion between teachers in the same section did not appear strong. Even chemistry teachers did not seem to interact much.

Figure 5.11: Teacher in the upper floor workroom looking at a scheme book

Interaction in Workroom

The teacher-talk here was varied and covered a wide range from learner discipline to the accommodation situation. Given that I had come to this school towards the end of term, I witnessed a lot of marking. Teachers were directed by the administration to give tests and prepare end of term reports for form five learners for parents to judge their children before they face the finals. So teachers were mainly marking tests so they could compile learners' reports. In both workrooms this was the main activity.

Amongst themselves, teachers also ridiculed strange answers from learners or the administration for demanding such a taxing activity on short notice. There was no talk about improving teaching or learning scenarios, except for the day in the workroom I spoke to Mr Maphane, a long serving physics teacher and Mr Nako one of the inexperienced chemistry teachers. The two were critical of the kind of teaching they claimed did not work, the type that was encouraged by the UB in-service department, such as integrated teaching. They told me that they would continue to attend professional development workshops, but that they do not embrace ideas from in-service workshops.

The Science Resources

Expansion of the science department had been completed in the early 2000, and housed all the chemistry and biology laboratories. The old chemistry labs had been converted to classrooms. From the old fleet of science laboratories, two were renovated and made physics specific.

A list of some of the facilities and other resources associated with science teaching was summarised in the table 5.1 above. The school appears to have excellent laboratories and adequate materials such as apparatus and chemicals. Shortages experienced included items such as stationery, which was a problem during the research study time. This led to cancellation or postponement of some tests as teachers could not run test papers in time. The chemistry laboratories were also lacking teaching aids such as posters. This left the laboratories especially the notice boards and walls bare. But in terms of chemicals and glassware needed for basic experiments, the school seemed to have those in abundance. All the three chemistry storerooms and the preparation room had had plenty of those in storage.

5.4.2 A Portrait of the School from the Perspective of the Teachers

Concerning facilities, the three teachers still believed that the department had various shortages affecting their teaching. Ms Nakedi talked about shortages such as not having enough laboratories affecting the teaching and organisation of practical sessions. She said '*I don't believe we have enough labs for the classes' (*Nakedi interview pg 5*)*. Ms Nakedi and Bolaane gave various examples of shortages they experienced that affected their teaching approaches at some points in the term. Ms Bolaane said about shortages,

> We had to give them papers to write their notes, and they had to transfer (later)... And the other thing that I mentioned was teaching materials… for instance I was teaching electrolysis, and I needed the Carbon electrodes and the *platinum electrodes*, I could only get carbon electrodes, towards the end that's only when the platinum electrodes came. But then I had finished teaching electrolysis. So there is a problem really with teaching materials. And if you could look at our labs…look into this lab, the notice boards are empty, we don't have large charts, we don't have large teaching materials that we could (display), so that the labs looks more (respectable)… (Bolaane interview pg 4)

Ms Nakedi added,

> We still are suffering without equipment like right now every year we have to do experiment doing practical for paper 4, we move around schools, junior secondary schools, borrowing things like retort stands, beakers… (Nakedi interview pg 5)

Mr Kopano, a new teacher was not so sure if there were any serious shortages, but said he had experienced shortage of material when '*I wanted to demonstrate… endothermic reaction under reaction changes with the form fives'* (Kopano interview pg 5).

Lack of some of the materials like posters in the department were partly blamed to the lack of active science club activities. Like Ms Bolaane said,

> …if we had maths and science club, then we could draw some of these things and put them on the notice boards, but we haven't done that … (Bolaane interview pg 5)

There seemed to be a problem with teachers' commitment to various school activities. For instance Mr Kopano said about teachers' commitment to work "*I look at it this way… it appears like something is moving just too slow with us…*' (Kopano interview pg 11). It is now necessary to look at the manner in which the school was run.

School Ecology and Management

There was a general feeling by the teachers that only peripheral activities were going well in the school. Teachers mentioned that the school was run well, lessons were running well as teachers and students attended lessons

> …if you dodge lessons, you will be caught and some measures will be taken and I think that's a very good thing that is happening (Bolaane interview pg 9)

The disciplinary measures applied to both learners and teachers. Ms Bolaane mentioned participation in various committees in the school as one of measures of involvement in the school. Teachers were held accountable for ensuring active participation,

> They are committees that are running they are heading… because they have to give reports during …staff meetings. So that's how teachers are involved in the running of the school (Bolaane interview pg 9)

Ms Nakedi thought that even though teachers were involved in committees, the administration still did not recognise their input. She said,

> …my view when it comes to our meetings, I mean we just go there, but the decisions are taken by the school management team …we are informed about everything. It's just information whether or not we agree. If they have taken a decision that it be that way… then it stays that way (Nakedi interview pg 11)

There seemed to be some feeling by the administration that as long as teachers were attending classes to teach and were involved in committees, then all was well. The school's governance did not appear too concerned with what teachers did outside their lessons. Teachers talked about the lack of urgency to support learners' learning as a

sign that teaching was not holistic. Ms Nakedi said this was reflected in the science department where teachers resist any form of extra work besides teaching. The proposal in a science meeting by Mr Kopano to have a science clinic running had been met with grumbling by many. Another proposal to revive the science club had not brought positive reaction too. Ms Nakedi told me that she had attended the science club following the department's meeting.

> I was just alone having gone there last time…they (students) were just alone there. There were no teachers (Nakedi interview pg 11)

The teachers thought there was lack of care about the overall duty to teach and empower learners beyond just lessons. As long as they are doing just the teaching, they did not feel obligated to do more. Hence, the feeling by Mr Kopano that the teachers were dragging their feet on non-teaching related activities.

The school seemed to have lost direction in the previous years, hence the introduction of a new principal at the beginning of the year (2005) to bring fresher leadership ideas. Mr Kopano was not even surprised that the school had been doing badly in the national league results and expected this to continue. The latest results had placed them at 22nd out of 27 government schools.

Ms Nakedi thought that the administration was failing to take full responsibility in ensuring effective teaching. For instance, talking about the lax approach by the administration concerning proposals to do things differently or desire to bring change:

> …right now as we speak, we talk about annual plans of which people have in other schools, in our school here, we have nothing like that… I suspect we might have stopped at the goals stage of the plan, we have not yet set the objectives, to help draw and complete the annual plan … these are things that are just brushed and done with very quickly and its clear they are not taking anything serious about it…I tend to take that we are just playing; we make a joke of all we are attempting to do (Nakedi interview pg 10)

The lack of progress concerning implementation of projects and innovative ideas seemed to be a result of poor leadership. Ms Nakedi said about the deteriorating will to progress,

> People don't follow up anything, so there is never any development that the school is really serious with…. (Nakedi interview pg 11)

Teachers showed mixed responses concerning the science department's position to implement.

Teacher's Support Mechanisms

Mr Maphane highlighted during a chat that there was lack of organised support for the new teachers coming into the science department. He said the new teachers still energetic usually ran out of steam, as they began to '*drown due to lack of support with time'* from the older mature teachers. He was mainly referring to Mr Kopano, who was a very enthusiastic teacher. He offered remedial lessons after school and even during weekends to form five students. Though he did not teach form five classes any more, his former class has continued to come for help. Mr Kopano too highlighted the lack of support or desire to work by teachers as lack of professionalism.

He said that teachers were only satisfied with teaching during normal school hours, and all extras are met with resistance. Ms Nakedi also concurred giving an example of the science club. She said there were a lot of students interested in the science club activities, but said most eventually gave up due to lack of support from teachers to carry out projects. The lack of support by teachers to bring innovative ideas to the department was described by Mr Kopano as a lack of vision by the school which he said did not have the right monitoring mechanisms.

There were various forms of support the department receives from surrounding schools during practical examinations. They helped the chemistry section with material, for instance chemicals and apparatus needed practical examinations. The same was true with exchange of teaching materials such as question papers from other senior secondary schools. The teachers talked about this practice as aimed at exposing learners to as much question range and pool as possible, to help prepare them for the final BGCSE examinations.

The teachers believed there was growing cooperation between chemistry teachers as they truly worked as a team. Ms Bolaane gave an example of such cooperation as demonstrated during monthly practical tests. During preparations of reagents, setting the laboratory up and supervision all teachers had came to help. She said it had never

happened in the past as it used to be the responsibility of teachers teaching the triple science classes. Though this was not compulsory, teachers were willing to offer help.

Ms Nakedi also expressed support in terms of help offered by management such as the head of science department, head of years, pastoral teacher and the principal. All these have to do with disciplining learners. Though the principal was still new, his test would be seen in terms of whether *'he sides with the teachers or with the students* Nakedi' (Nakedi interview pg 11). This appeared a big issue with teachers as they felt that their authority was being degraded. The kind of help or support the teachers needed was to do with organisational issues in the department and disciplinary measures the administration team could offer.

Support was not (immediately) seen in terms of offering assistance to teaching and learning activities. This was true even though Ms Nakedi cited some problematic areas in the BGCSE curriculum such as content covering the newly introduced topics and other problematic areas such as the lattice structure of sodium chloride. Ms Bolaane and Mr Kopano talked about some help they received from colleagues, such as at times approaching them about depth of concepts to cover. Ms Bolaane said about teachers,

> They really cooperate, if there is one concept you don't understand you can go to one teacher, ask and then you sit down. Even with our markings, the way we mark our tests we prepare some marking key, common marking key, so we prepare it, you compare it with another teacher and see if you have prepared the same thing. So I think that is a lot of being together (Bolaane interview pg 5)

Mr Kopano also approached colleagues on issues surrounding setting test questions, to gain insight into the readability and level of difficulty. For instance Mr Kopano approached colleagues to find their opinion or critique his work

> The way I asked questions in a test they told me … it is in a form that cannot be understood by those kind of students so try to use this kind of language… (Kopano interview pg 7)

This seemed to suggest that chemistry teachers did interact even though they were not housed in the same place, especially on issues concerning the teaching and learning of chemistry. Though Mr Kopano appreciated such cooperation in terms of setting tests,

he did not want the department and colleagues to go as far as outlining teaching methods for him. Mr Kopano said,

> I think it is best that you are left to do things the way you feel you are comfortable with and can do better than teaching methods being imposed on you… (Kopano interview pg 8)

Due to separation of members of the chemistry section between workrooms, there seem to be no pressure to copy what others were doing. The more experienced teachers had a different opinion, for instance Ms Bolaane thought not sharing a place was also detrimental to chemistry teaching:

> … if you were to discuss it will be easier if you are in one place than scattered in different places (Bolaane interview pg 6).

The two younger teachers did not share the workroom with the more experienced teacher Ms Nakedi. All the three teachers had their own distinct ways of teaching. Despite a low PCK by Mr Kopano, he had not requested colleagues to offer him formal help concerning teaching, which seems to suggest that the relationship was only superficial.

Teacher's Views about Support from In-Service Programs

There were two regional workshops held every year. Each senior secondary school had to send a member from each science subject area as representative. Issues that were touched on revolved around the teaching and learning of science. The department's practice had always been to send new teachers to such activities. Old teachers usually claimed that they '*are used to this things*' (Nakedi interview pg 6). The perception by the teachers was that there was not much to benefit from these activities, as they were always the same. The fact that the attendants do not formally organise a forum to report back meant it was not of much use to those who had not attended *'…there is nothing like a workshop that can be held in school to explain what was going on there'* (Nakedi interview pg 6). When reporting was done, it was very superficial as this was done during meetings. No internal workshops were organised to orientate other teachers. The result was that even ideas affecting teaching never got to members of the department.

The teachers associated all of these factors with poor monitoring:

> I think with monitoring really that's a…real problem that we are having … there are quite a number of things that we talk about … there is no one who is really checking if people are doing it… they just say things but they don't follow up (Bolaane interview pg 7)

Though monitoring was a major concern, they felt that the science senior teacher was trying hard in other areas. For instance, he had followed up on the newly introduced practical tests which were done once every month. The science senior teacher *'tries to monitor…' (*Nakedi interview pg 7) some agreed changes, like to find out how far teachers were with preparation weeks before that date, which was not observed from the higher offices.

Motivation of Teachers to Work in This School

A number of teachers talked a lot about being dissatisfied with teaching as a job. Mr Nako, who holds a BSc (chemistry major) and PGDE, told me that teachers who first took pure science degrees and later taking PGDE to teach had found it hard to accept teaching as a job for life. This was a concern because the three inexperienced teachers in chemistry held this qualification, which seemed to suggest that they are only there as a stepping stone for greener pastures.

It was also in this department that the teachers had openly stated that they would be happy to accept jobs elsewhere should they came up. The reason for not settling into the job was that older teachers in the department were also unsettled. The search for alternative jobs seemed to have been revived after three members of the science department had left teaching to join various government departments. For example, the latest was a biology teacher who had joined the election commission department. A chemistry teacher and a physics teacher had earlier left teaching, joining other government departments.

Mr Kopano told me that his main desire would have been to work as a chemist in industry. Despite feeling misplaced, he said that he has to be professional, and fulfil his employment obligations to support the learners. Without committing to teaching, he said,

> It wouldn't be different (working elsewhere). Because I believe that a person should do what he has been hired for, like I am not supposed to earn the salary

> for doing nothing. I am hired to teach these kids, and I was not just employed to just teach and it ends there, I have to teach them to pass as well. So that's what motivates me… (Kopano interview pg 12)

Mr Kopano was enthusiastic, and eager to give more, but colleagues were not ready as they were happy to give just enough. He said about other teachers' lack of professionalism,

> I think the staff itself appears like they are too much relaxed. It appears like there are not too much into the vision… I think you see maybe I am comparing our school with Ngami SSS where my brother teaches…because the way he talks about it, that they are always doing this… doing that, those are things that I think I don't see us doing...it appears like something is moving just too slow with us… (Kopano interview pg 11)

According to Mr Kopano, there appeared to be no pressure to work hard or to come up with ideas of how to do things better for learners' learning.

Teachers Perception About The learners

This was a non-boarding school and so all learners stayed within the village. A number of them originated from the surrounding villages. Their parents had to assist them find rented accommodation within the village. Hence a lot of these learners stayed alone without custodianship of parents or relatives. There was a perception by the teachers that this lack of supervision was negatively impacting their studies as some spent most of their time outside school hours without control. During a PTA meeting I attended, teachers used this as the main reason why Lesedi SSS never did well in the national examination. Teacher claimed students devoted very little time to their studies. This was worrisome to parents and teachers as the school poorly performed again.

> … You will hear a case when the parent comes here saying, because they stay alone … they have all the freedom to do all … they want to do… (like) the bar (Nakedi interview pg 14)

Teachers also blamed this on the '*calibre of students we have'* and the 'poor catchments areas' the school is dependent on. Students were said to lack drive to study, as parents seem to be distant and unsupportive.

5.4.3 Summary of Lesedi SSS

Lesedi SSS was one of the old schools in the country. It generally had good resources such as classrooms and laboratories at par with other schools. The science laboratories including a number of other buildings were new. Having adequate classrooms meant laboratories were only used for the teaching of science purposes. Teachers generally did not think that there had enough facilities to implement the curriculum as intended. Laboratories were said to be occupied all the time making it difficult to have space to prepare and setup material for experiments. Teachers also mentioned other shortages such as lack of apparatus, posters and some chemicals.

The school appeared challenged in the following areas:

- Lack of basic resources such as stationary, posters and some chemicals mentioned by the teachers
- Lack of support to young and inexperienced teachers which affected the mood and work ethics of the teachers
- Lack of communal practice setup manifested in some ways such as lack of desire to implement new ideas
- Lack of desire to work and help learners, teachers were said to just do just enough work like teaching and resisted to participate in enriching programs such as the science clinic and the science club activities.
- Poor home learning/studying environments for learners. Teachers also raised the issues of learners staying without guardians as a big problem. Lesedi SSS as a non boarding school they felt is also compounding to the problem of performing poorly every year. They associated learner staying without supervision as leading to little devotion of time to study.

5.5 Patterns, Relationships and Themes

Having drawn summarising statements, it was important to start looking for similarities or differences within data concerning the four schools. Use of typologies analysis made it possible to have ideas of the kind of patterns, relationships, and themes that could be present in the data. From the summaries created for each school, it was possible to start seeing patterns, relationships and themes emerging. Patterns in this study were taken to include regularities which could either the things happening

in the same way or happening predictably different ways. To search for relationships, links that were evident or not between teachers, departments and schools were made. This section also looked at integrating concepts covered for each school about the resources, the teachers and school factors to formulate statements that meaningfully attempted to bring all the data together. The process was enhanced by writing, making visual representations mainly in the form of tables, then looking for relationships in between. The last part involved writing patterns and relationships as generalisations. Generalisations expressed relationships between teachers in the same school/department, teachers in different departments/school and teachers in different departments/schools. The following strands were used: resources, administration, cohesion (unity) and cooperation.

Similarities and Differences Found In the School Setting

There were a number of areas as depicted from the interviews and general observations of the school settings that pointed towards similarities and differences in the way the schools, the science departments and especially the chemistry sections functioned. The most standing out school settings related to the resources, how the teachers related and perceived their school, the science department and the chemistry section. The table below helps to outline some of the issues the teachers perceived as important in their day-to-day running of their departments and work in general.

Table 5.2: Summary of schools' ecology and management relations

	School (SSS)	**Dombo-shaba**	**Tagala**	**Maru**	**Lesedi**
1	Leadership type	Top-down	Top-down	Top-down	Top-down
2	Flow of activities/ effectiveness	Poor	Poor	Good	Poor
3	Satisfaction with administration	Poor	Poor	Poor	Poor
4	Teacher involved in decision making	Poor	Poor	Poor	Poor
5	Teacher relation with principal	Poor	Poor	Poor	New Principal
6	Autonomy of science sections	Good	Poor	Good	Poor
7	Innovativeness of department	Good	Poor	Good	Poor
8	Learners' discipline from administration	Poor	Poor	Good	Good
9	Support for learners	Poor	Poor	Good	Poor

The table 5.2 shows some issues related to all the schools that seemed to have great influence to the identities and forming a bigger part of the characteristics of the science departments. These included the school facilities related to chemistry teaching, the school ecology and management which brought unique styles of leadership, flow of activities within the schools, to some extent also bringing or

affecting the mood of teachers, and how teachers reacted as a department or unit of science.

Poor Leadership

Teachers in all the schools were generally not satisfied with the way the schools were run. As table 5.2 indicate, teachers generally rated their leadership poorly. They viewed the school administrators as un-involving and contributing negatively to the flow of activities as manifested through lack of discipline, commitment by both teachers and students to work. There was a feeling that the principals and the management team controlled everything. This is so in spite of the fact that teachers were involved in heading internal committees, supervision of students, discussions of issues during meetings. According to the teachers, when decisions were taken, teachers' contributions were not considered which they equalled to no involvement at all.

Unity in Science Departments

Dissatisfaction with administration mainly led to two types of reactions from the teachers, they either broke-down, performed poorly or strengthened and wanted to do more for the sake of learners. Certain conditions surrounding the science department had to be met for each teacher (school) to take either route. It appeared that where there was a greater working relationship between teachers, they came up with coping strategies for themselves and structures to help learners. On the other hand, it appeared that where there was less cohesion in the department teachers seemed to break-down and functioned less. In this case scenario, mainly experienced teachers appeared to want to just do enough teaching. Strength of cohesion at departmental level appeared to be the main driving force in teachers' functionalities. All the schools according to the teachers, had (and data supports this) poor leadership systems. Consequently, all teachers were not happy with the state of affairs.

Cohesion and Cooperation between Science Teachers

Though all the teachers were dissatisfied with their leadership, it appeared that Maru SSS was the most effective in terms of having order, that is teachers doing their work, and students under control and doing their work too. The principal was described as running the school singly. This has led to teachers wholly frustrated by the leadership

approach. In Lesedi SSS, teachers are braced by a new charismatic leader who has not yet stamped his leadership style in the school. Teachers are still unhappy with flow of things as nothing seems to have improved in the school. The leadership was described as top-down by the teachers due to teachers' contributions never taken on board whenever decisions are made. Teachers in Tagala SSS cited different reasons for their dissatisfaction with their leadership. The principal was described as weak and lacking leadership qualities. The incompetence of the principal was believed to have led to disintegration of order and laxity in the school. Students were said to be less committed to doing school work, whilst teachers are devoting little time to work. The principal's presence was not felt in the school especially in the science department. Domboshaba SSS was also described by the teachers as lacking order and discipline especially the students due to weak leadership. Poor management in school was also associated with the degeneration of many other things in the school such as excellence in sports and academics. Frequent change of management, especially the principal and deputy posts have led to lack of continuity.

It could be said that all the leadership in the schools followed a same pattern. Teachers are consulted to make contributions, but their ideas are never considered. This had generally left the teachers very frustrated especially by the lack of active participation in school issues and students indiscipline. Tagala SSS and Domboshaba SSS were the most affected concerning ill discipline and deteriorating academic results. Generally in all the schools, teachers felt very distant from the administration due to their insignificant contributions to decision making or general lack of support. A summary of areas teachers felt little contributions is given in table 5.3.

Table 5.3 Summary of areas teachers felt uninvolved / problematic areas

	Senior Secondary School, SSS	**Dombo -shaba**	**Tagala**	**Maru**	**Lesedi**
1	Handling discipline (school)	poor	poor	Good	Good
2	Studies (times/ supervision)	Poor	Good	Good	poor
4	Security issues (e.g. laboratories)	Poor	Good	Fair	Good
5	Assignment/test (frequency)	Good	Good	Poor	Good
6	Approving innovations/intention (accommodating)	Good	Good	Good	Poor
7	Monitoring mechanisms (lack of)	Poor	Poor	Poor	Poor
8	Follow ups for intentions/innovations (lack of)	Good	Poor	Poor	Poor

Teachers in different schools seemed to be affected differently by the management systems. With the management factors held constant, a close observation at departmental level revealed that some departments seemed more orderly, working more as a team, getting good chemistry results and being more innovative than others. Cohesion and nature of practice at departmental level seemed key to softening the negative effects associated with the top-down leadership styles viewed pessimistically by the teachers.

In all the schools investigated, majority of teachers said during the interviews that they had lost interest in teaching as indicated in the table above. But it was clear also that teachers in various departments made attempts to make their work tolerable and at least making their departments functional despite feeling less committed to the school vision. There appeared to be differences of impact caused by a lack of interest from teachers. From the table above, it could be said that it was in departments were teachers were a lot closer together, working as a community were they seemed to cope better.

Closeness of teachers in Domboshaba and Maru secondary schools led to them cooperating more both at departmental level and at (chemistry) section level. In such departments teachers tried to come up with ideas to make their sections work better. Maru teachers visited schools in their region, and adopted the science clinic and tea club from the visited science departments. These seem to have made teachers closer, and work together as a team. The same could be said about Domboshaba, where teachers were trying to come up with innovative ideas to counter inefficiency in the school. For instance, they came up with the idea of sourcing external funding to buy their own photocopying and printing facilities. The department also runs its own disciplinary committee to counter disruptive behaviour in classes. Teachers seemed to do the best for their departments despite that they did seem to want show alliance to the school leadership.

Departments where teachers were less close to one another were characterised by less support to each other. Backstabbing was rife. Also obvious was lack of functional support structures to either encourage cohesion or to support learning. For instance, in Lesedi SSS some teachers in the department came up with ideas about the reviving

the science club including introducing the science clinic to support learners. Other teachers resisted these and showed less commitment by not turning up to support learners.

Tagala SSS, like Lesedi SSS science departments did not have a tea club. There was generally more backstabbing in these departments than in other schools. Backstabbing seemed to affect negatively the young and in-experienced teachers more. In-experienced teachers felt that the more experienced teachers were trying to damage their growth through withdrawing teaching materials like chemicals, books and hand-outs from public view.

The lack of cohesion and cooperation led the inexperienced teachers more vulnerable and lacking proper mentoring. This was demonstrated by the new teachers especially in the less functional departments who seemed to have a lot expected from them without much assistance. This included teaching the more demanding triple science stream and coordinating a sub-department.

Chapter 5 Concluding Statements

This chapter seems to suggest that the strength of the departments in Botswana senior secondary schools and not just the resources played a greater influence in the teaching and learning of chemistry.

From all the schools investigated it was observed that all departments operated with more of less similar capacities such as: departmental resources (facilities), chemistry related facilities and teacher qualifications.

Though teachers voiced concerns over certain shortages specific to their departments and at times chemistry subject specific, there seemed not to be a great deal of difference in terms of facilities related to chemistry teaching.

Differences in Schools

The main differences in schools could be attributed to the differences in the way the schools were run (that is support to learners, teachers and schools' ecology and management systems). Teachers in the schools seemed dissatisfied with the leadership

system. In all schools, teachers felt that there was too much top-down control with little input allowed from them. This has led to big gaps being created between the teachers and the administration. There was a general perception by teachers that learners were treated better than the teachers. Teachers felt lack of team-work with the administration has led to too much learner's freedom at the expense of discipline and focus to learning. Administration formed an important influence in the way teachers perceived the work environment.

In all the schools there was displeasure by all teachers with the way the administration was operating. Teachers in departments, especially chemistry sections where cohesion was greater, their teaching was not totally influenced by factors outside their departments. They continued to work better, support learners more, support each other more through cooperation.

Cohesion and Cooperation in Schools

What seemed to be apparent in the schools is that some schools have more cohesion in the science (chemistry) department. For instance, in Maru SSS, chemistry teachers were isolated from the rest of the other science teachers. Domboshaba SSS also had chemistry and physics teachers isolated from the biology teachers. In these departments, there seemed to be more cooperation between the teachers, sharing teaching materials and even possessing more energy to teach, run departmental, run support structures for learners' learning like the science club and the science clinics. Domboshaba SSS science teachers were well organised they even chaired a student's disciplinary committee. They also came up with innovative ideas such as sourcing money from outside school to buy their own photocopying and printing facilities. In Tagala SSS and Lesedi SSS, all teachers were haphazardly mixed. There were no systematic arrangements between the two departments. There was no tea club run in these departments such that during tea break, all teachers departed to their homes. It was also in these departments that there was less cooperation between chemistry teachers, less support and even opposition to science clinic and science club. The science teachers (and specifically chemistry teachers) were not working as a team.

In schools were there was less teacher cohesion, teachers' morale was easily broken down by factors outside the department that worked against them such ineffectiveness of the administration or their dislike or lack of support from the administration.

5.6 Potential to Implement

Looking at the structures supporting learning, it could be said that two schools Domboshaba SSS and Maru SSS appeared to have had a better potential to implement the new chemistry curriculum. This was due to the commitment of teachers, not as individuals but as departments to improve teaching and learning in their schools in the form of support structures to each other (teachers) and the learners. At Tagala SSS and Lesedi SSS it was documented that the schools had equally good infrastructure to implement. But teachers were too individualistic, less committed to work and low structures to support teaching and learning as a department meant there was generally a restricted move towards supporting the realisation of the BGCSE curriculum. It was important to use the Rogan and Grayson's framework to help compare the schools. The operational level was used in this regard. First a description of how it was used in the study will be made.

5.7 Determining Operational Levels

To determine the operational levels of the schools the guidelines from the Rogan and Grayson (2003) framework were used. A template adopted from this framework is shown in the appendix C. In table 5.4, the indicators relating to the construct 'capacity to support innovation' has been outlined. This includes the different levels they are to be conceptualised. To determine the schools' level of operation for each school requires first identification of indicators depicting current practice or level of capacity which are then compared with template indicators. Before the current level of capacity of the schools is outlined, it is worth noting that a template remodelled under the Rogan and Grayson (2003) framework, showing the indicator factors for Botswana schools has been described in chapter 4.

Using the Rogan and Grayson's (2003) Template (Appendix B)

The template shows the indicators and the corresponding levels. This helps to locate the operational level of the schools. For instance, after outlining the practice

indicators found in a school (table 5.4), it was possible to determine the level of capacity through the use of the scale (Appendix B). Such a match should be possible because of comparison of what was found on ground and what exits in the template, giving the operational level.

Operational Levels for Capacity to Support Innovation

Table 5.4 below summarises what was actually observed and seen happening in the four schools concerning their capacities to support teaching and learning. The dimensions found under the profile of capacity to support innovation (Rogan & Grayson, 2003) used to outline the capacity indicators were the physical resources, teacher factors, and school ecology and management systems. It is important to note that the dimension 'learner-factors' was not included in later discussions as most of the data about the learners came mainly from the teachers only. Therefore, the data did not provide enough information to outline all the learner factor indicators. Table 5.4 gives a detailed summary of the current indicators which should help determine the operational level.

Table 5.4: Capacity indicators of the four schools

	School Setting	Domboshaba SSS	Tagala SSS	Maru SSS	Lesedi SSS
1	**Physical Resources**	Excellent buildings, adequate classrooms School library & resource centre Textbooks provided 3 Chemistry laboratories Good teaching and learning resources Sufficient chemistry apparatus Good photocopying facilities (centralized)			
		Underdeveloped grounds Inadequate classrooms	Well developed sports facilities	Underdeveloped grounds	Underdeveloped grounds
2	**Teacher Factors**	All teachers qualified Excellent content knowledge Low teaching experience Some teachers in chemistry section participated in PD at some point			
		Teachers highly committed to teaching and work Teachers makes extra effort to change and improve Willingness to collaborate & cooperate Good vision for innovation	Teachers committed to teaching and work Teachers makes effort to change and improve Limited opportunities to collaborate Vision for innovation limited	Teachers highly committed to teaching and work Teachers makes extra effort to change and improve Willingness to collaborate & cooperate Good vision for innovation	Generally low levels of teachers' commitment to teaching and work Teachers makes little effort to change and improve Limited opportunities to collaborate Vision for innovation lacking
3	Learner Factors • Support to learners • Academic • Social/recreational	Learners reasonably fluent in English (all fluent in Setswana) Good study & feeding (breakfast and lunch) support system at school Majority of learners not taking responsibility for their learning	Majority of learners not fluent in English (all fluent in Setswana) Boarding facility provided Basic study needs catered for Basic feeding support catered for at school Majority of learners not taking responsibility for their learning	Majority of learners not fluent in English & Setswana Boarding facility, feeding support and study needs catered for Enrichment academic needs catered for in science department (science clinic, quiz contests, science club) Majority of learners not taking responsibility for their learning	Majority of learners not fluent in English (most or all fluent in Setswana) Boarding facility provided Basic study needs catered for Basic feeding support catered for at school Majority of learners not taking responsibility for their learning
4	**School Management**	All teaching routines in progress Teachers participated in various committees Teachers played active role in various committees Teachers played minimal role in decision making Teachers shared responsibility in running the school (supervision of studies, feeding, sports) All teaching routines progress well			

		Class lists; time table properly implemented (except form fours on first two weeks at school) Principal's presence not felt Management lacks vision	Class lists; time table properly implemented (shortage of teachers in some subjects at beginning of year caused disorder) Teaching activities not orderly Management lacked vision	Class lists; time table properly implemented Principal's presence not felt in school (except at school assembly) Administration team's presence felt in school	Class lists, timetables properly implemented Principals' presence felt by teachers & not learners
		-	-	-	-
	School Ecology	School functions- responsibility shared only to some extent Teachers in science department committed to making school work School seems to lack planning for support/vision	School functions- Teachers in science department committed to some extent School / department seems to lack planning for support /vision Poor supervision of change	Teachers in science department committed to making their department work Teachers disgruntled with administration Various functional structures in place to support improvement	Teachers in science dept only minimally committed to making own department work Teachers disgruntled with school administration Some functional structures in place to support improvement
	Science Department Ecology	*Routines well run* *Senior teachers' presence felt* *Teachers play active role in running the department* *Teachers committed to making sc dept work* *Visionary and participatory department*	*Routines not well run in science department (cleaning)* *HOD not involved in departmental issues* *Teachers* *Teachers disjointed and lack unity* *Teachers/science department lack vision*	*Routines well run* *HoD & Senior teacher's presence felt* *Teachers play active role in running the department* *Teachers work in unity* *Teachers work in collaboration & cooperate* *Visionary and participatory department*	*Senior teacher's presence felt in science department* *Teachers play minimal role in trying to make the department work* *Teachers lack commitment to change and improve* *Superficial collaboration, cooperation and work in unity*

Table 5.4: Capacity indicators of the four schools (cont.)

The table gives only the most obvious dimensions found in the four schools. These are the areas that dominated the talks of the teachers in their work place as well as during the interviews. According to the results, it could be said that the different schools had similar factors which influenced implementation of the chemistry curriculum.

5.8 The Operational levels for the four Senior Secondary Schools

To synthesise the findings, it was necessary to first convert the school indicators summarised in table 5.4 to operational levels. This was made by matching the indicators (table 5.4) with summaries from the remodelled template in Appendix B. The operational levels of the schools were found to be as given below.

Table 5.5: The levels of operation of teachers at the schools

Names	Domboshaba SSS	Tagala SSS	Maru SSS	Lesedi SSS
Physical Resources	3.5	3.5	3.5	3.5
Teacher Factors	3	2	3	2
Ecology & Management	2.5	2.5	2.5	2.5

The four sub-constructs and their level were represented diagrammatically in figure 5.12, which makes it possible to make comparisons between the schools.

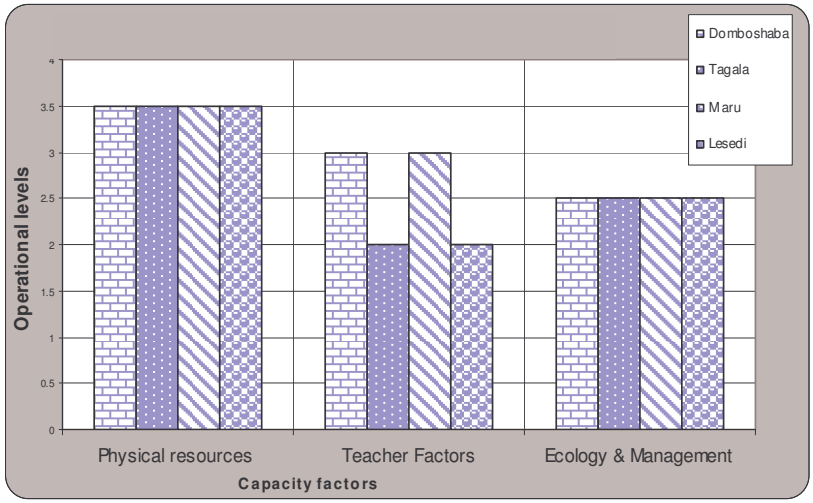


Figure 5.12: Schools' current capacity factors

From the figure above, it is clear that all school had good physical resources needed to effect the teaching of chemistry in senior secondary schools. This is so because at this level there is sufficiency in most of the basic items needed to teach chemistry. Close

scrutiny revealed that there were still some areas which need improvement concerning resources and utilisation. According to the Rogan and Grayson guidelines, there are some areas which can still be improved. The figure also showed that there are varied teacher factors coming from different schools. Domboshaba SSS and Maru SSS had greater capacity in terms of teacher factors. This was mainly due to the structures in the departments which improved teachers' morale to work in their schools, the higher number of teachers with experience which affected resource utilisation.

At Tagala and Lesedi SSS, teacher capacities are depicted as low by the bar chart above. This could be associated with the generally high number of inexperienced teachers who participated and the generally less favourable work conditions they cited. Teachers' morale and willingness to improve teaching was generally low in these two schools. Low morale was also associated with the nature of relation between the administration and the teachers.

Generally in all the four schools, the bar showing capacity coming from the ecology and management systems of the school is about half of full scale. This could be associated with the teachers not rating their schools highly due to what they perceived as lack of involvement in school issues, especially in making decisions. This seemed to show that the way teachers viewed the school's administration was very important in how they eventually performed their duties. It is also possible that the lack of 'smoothing effect' due to departure by majority of experienced foreign teachers could have caused this problem due to lack of good mentoring. Majority of the teaching force at the time were young and inexperienced teachers due to the localisation process.

Following the discussion of all the factors making up the schools' settings it was important to now explore what was seen happening inside classrooms. The format and structures of the chapters was discussed below.

CHAPTER 6 DOMBOSHABA SSS

The purpose of these chapters was to explore how chemistry teachers in the investigated senior secondary schools reflected on the changes of the chemistry curriculum, their epistemological beliefs and how their teaching goals related to their use of learner-centred and laboratory activities. The sub-research questions included what the teachers perceived as the changes in curriculum and what they consider the curriculum meant to them and their schools.

This chapter therefore looked at the teachers' perception of the curriculum change and instructional goals, what could be said eventually led to their teaching actions. The next chapters explored the types of hands-on or minds-on activities with which teachers engaged students. Findings for these chapters were obtained mainly from classroom observations and teacher interview questions. Several issues were looked for during analysis of interviews and the classroom field notes based on the analytical framework discussed in chapter 4. Issues looked at related to how:

- the teachers interpreted the curriculum and its intentions
- teachers elicited learners' prior knowledge during teaching
- teachers promoted learner participation (learner-centred teaching and learning)
- the type of hands-on and minds-on activities promoted during chemistry teaching
- practical work formed part of teachers' teaching repertoire

The above criteria were based on the intention of the BGCSE chemistry curriculum which calls for the contextualisation of knowledge, learners having to construct their own knowledge during teaching and learning and involvement in scientific investigations. These chapters have therefore set out to discuss the findings from data under the following broad areas:

1. What the BGCSE curriculum meant for each participant. Here I examined teachers' concepts of curriculum change and also what curriculum implementation entails in their school. The teachers' views relating to changes in curriculum were grouped under the three general categories relating to
    - Changes in terms of content
    - Changes in terms of assessment

- Changes in terms of teaching and learning opportunities

2. Another broad category to be discussed concerned findings from the classroom observations data to find how teaching of chemistry manifested in the teachers' classrooms. This section looked at what the teachers actually included in their teaching repertoires. The extent to which teachers allowed learners to be involved in the lesson proceedings is particularly important. I therefore tried to identify instances where teachers offered learners opportunities for learner-directed hands-on and mentally challenging activities. One of the aims of introducing the BGCSE curriculum was to improve student learning. Hence, one of the measures of success in implementing the BGCSE curriculum in this study was considered in terms of students' participation in lessons. The section also documents the type of hands-on and minds-on activities the teachers engage their learners.

3. The third component of this chapter looked specifically at the use of practical work in chemistry teaching. Teachers' understanding and interpretation of what practical work was related to how it affects their teaching action and how much they employ it as a teaching method. During interviews teachers identified experimentation as an important component of teaching chemistry in the new BGCSE curriculum. The curriculum policy also mandates teachers to increase exposure to hands-on activities so as to help students develop various practical related skills rather than to just transmit information. Hence, this part describes how teachers have so far changed their styles of teaching being more responsible in shaping the curriculum rather toward learners' participation than to just transmit information.

Before each school was scrutinised, background information concerning the researched teachers was summarised in the table below:

Table 6.1: Secondary school, teacher & classroom related information

Name of school SSS	Teacher	Qualification	Teaching experience	Science streams	No. of classroom observations
Dombo-shaba	Mr Kgabo	BSc	High	Triple/Single	6
	Ms Malane	BEd. Sc	High	Double/Triple	7
	Mr Pula	BEd. Sc	High	Double/single	7
Tagala	Mano/M	BEd. Sc	Low	Triple/single	9
	Mr Mokone	BSc	Low	Double/single	8
Maru	Mr Mpho	BEd. Sc	High	Triple/Double	11
	Mr Bose	BSc	High	Triple/Single	9
	Mr Sunny	BEd. Sc	Low	Double /Single	9
Lesedi	Ms Nakedi	BEd. Sc	High	Triple/Single	9
	Ms Bolaane	BEd. Sc	Medium	Single/triple	8
	Mr Kopano	BSc	Low	Double/single	7
TOTAL					**90**

Teaching experience was categorised in this study as high, medium or low. The categories were defined as follows:

- High [>5]: The most highly experienced teachers in the schools visited were considered to be those who had taken part in teaching the old curriculum. That is those who joined the teaching service prior to 1998 to at least year 2000. These teachers had seen a cycle of at least 5 BGCSE examinations.
- Medium [2 - 4]: Teachers of medium teaching experience were considered to be those who started the service from year 2001. These teachers have been on the field at most 4 years by the time of this research study.
- Low [0 - 2]: Teachers of low teaching experience where considered as those who had been in the field for some few months to about 2 years in the field. This excluded teachers who had accumulated teaching experience at junior secondary teaching integrated science and joining senior secondary teaching later in their career.

Generally chemistry teachers in Botswana secondary schools have little teaching experience. This has been attributed to the localisation process which saw the majority of experienced expatriate teachers giving way to newly graduated local teachers. None of the schools involved in the study had Batswana chemistry teachers who had taught prior to the mid 90's.

Class Selection

Table 6.1 shows that the group of classes selected represented the three different types of chemistry curriculum offered at the senior secondary school. The selection was being made mindful of the two different levels (form 4 and form 5), the levels at

which the BGCSE curriculum is offered. The selection was also mindful of the three different science streams offered, the single, the double and the triple sciences. The observed teachers were interviewed once, and observed teaching several times.

The various teaching methods executed by the teachers were summarised in tables in various chapters. The teaching methods were defined as follows in this study:

Definitions of Terms

- A teaching method was recorded as having occurred during a lesson when it was used for the duration of a lesson, or at a particular point during the lesson, hence the number of teaching approaches does not equate to the number of observations made per teacher. For instance, a lecture instruction followed by a demonstration would be recorded as two different approaches. Two in this case does not equate to two observations.
- A lecture method represented a teacher dominated approaches during a lesson such as a teacher talk, note writing with little participation in the classroom discourse by the learners.
- A whole class discussion included what was observed as a lesson whose proceedings were a mixture of teacher-learner and learner-learner talks. Such talks were usually directed by the teacher.
- Experiments were described as either a demonstration or learner oriented. Demonstrations were considered as those practicals were learners were minimally involved except to just observe the proceedings. The major hands-on activities were done by the teacher. An experiment was learner oriented when the learners were the ones involved in manipulating apparatus individually or in small groups.
- Learner presentations were activities involving learners taking over from the teacher to deliver or share their investigations through a lecture or presentation.

Following summaries giving the schools and teachers backgrounds, it was now important to scrutinise individual schools and their teachers. Categories cited above were used to determine what was happening inside classroom. First Domboshaba SSS will be looked at first under chapter 6.

Introduction

The purpose of this chapter is to explore how chemistry teachers at Domboshaba SSS reflected on the changes of the new BGCSE chemistry curriculum. The sub-research questions involved finding out what teachers perceived as the changes in curriculum and what implementation of the BGCSE curriculum meant to them. The chapter also looks at the general implementation that was the approaches the teachers adopted in teaching chemistry at Domboshaba SSS. Interview and classroom observation data was used.

6.1 Teachers' Profile

Information about teachers has been presented in table 6.1 and 6.2, but it is briefly explained for convenience. Teachers in Domboshaba SSS were observed at the beginning of the term, just after the schools returned from recess. The observed teachers were of comparable teaching experience. This made it interesting to note the way they viewed the curriculum change and teaching goals and also the kind of experience they had acquired having taught together for a while. All of them started their teaching soon after the introduction of the new curriculum, which meant their interaction with the old curriculum had only been during their secondary school days.

Table 6.2: A summary of the chemistry teachers' pedagogical profiles

	Domboshaba SSS		
Pedagogical approaches	Kgabo	Malane	Pula
Lecture method	4 (T)	4 (T/S)	6 (D/S)
Whole class discussion	4 (T/S)	6 (S)	1 (S)
Group discussion	-	2 (T)	-
Experimentation (teacher demo)	-	3 (D/S)	2 (D/S)
Experimentation (Learner)	3 (T/S)	3 (T/S)	4 (D/S)
Learner Presentations	-	-	-

6.2 Teachers' Perceptions about the Curriculum Change

Teachers' perceptions about curriculum changes were grouped into three categories. The categories related to their views relating changes to content, assessment and teaching and learning goals. Only interview data was used in this section.

6.2.1 Curriculum Changes in Terms of the Syllabus

Curriculum change was not immediately obvious to the teachers, as Mr Kgabo said, '*nothing much has changed…' (*Kgabo interview, pg 1) and Ms Malane also agreed saying '*there isn't much change really…' (*Malane interview, pg 2*)* that has occurred. Further scrutiny revealed that the teachers viewed the changes in terms of chemistry content.

Mr Kgabo, whose view represented the general view of the teachers, talked about changes as relating to syllabus and its content of chemistry. He believed that the way the syllabus was structured had brought more application of science than the case in the past. Ms Malane was clearer when she talked of changes. For instance, she viewed the changes related to the syllabus as related to newly introduced topics like '*recycling, energy sources…' (*Malane interview, pg 2). Changes were found in the form of '*even with some old topics, you will find that objectives were restructured, sort of removing some content…'* (Malane interview, pg 2). According to her, the intention was to remove the less relevant and also lower the load of syllabus. But the teachers felt that introducing more new topics and objectives than were removed has led to '*the syllabus still appearing a bit longer'* (Malane interview, pg 2).

Change in syllabus was not limited to content only, change of the syllabus was also attached to the requirements of the chemistry curriculum such as application of science. Mr Kgabo commented '*The way it is structured, there is no way you cannot talk about application of science*' (Kgabo interview, pg 1). Ms Malane thought that contextualized topics like acids and bases ensured that no concepts was taught without relating it to the day-to-day usage like '*tooth brushing… application of fertilizers in the soil' (*Malane interview, pg 6).

Teachers also viewed the curriculum changes at policy level as relating to assessment.

6.2.2 Changes in Terms of Assessment

The teachers viewed one of the main changes of the syllabus as relating to assessment. For instance, Ms Malane talked about the changes as outlined in the syllabus as relating to the examinations. She said that the triple science students now had to write four examination papers instead of three as in the past. The assessment

change was said to be more pronounced with the single and double science groups, due to introduction of paper four '*which is the main change' (*Malane interview, pg 3). Paper four which:

> …has been introduced to single and double… is more like a practical, but it is theory form of practical (Malane interview, pg 3)

According to her, the introduced assessment made different demands on teaching single and double science streams compared to the past. The teachers thought that as a result of these demands, learners should be exposed to:

> …demonstrations and practical work…In most cases you find that you really have to give the students the apparatus … to use so that they see that and that, so that they can be able to answer questions (Malane interview, pg 3)

Ms Malane thought that in the past demands had not been made on the single and double streams. Generally the teachers at Domboshaba SSS thought such as change in teaching was necessary as there was a new demand for knowledge of apparatus and practical skills. The required skills included taking readings from drawing, making calculations and interpreting results from provided data. Due to these extra demands, Mr Kgabo thought that now all the teachers had to give demonstrations and practical work to all streams, so as to expose learners to apparatus. He thought examination demand also called for regular internal assignments and tests.

Teachers viewed the expansion of the syllabus, especially that new topics have been added and the demand to relate topics with context and assessment demands as having compounded the problem of completing the syllabus.

6.2.3 Curriculum Changes in Terms Of Teaching Practice

The teachers at Domboshaba SSS saw new teaching approaches as being influenced by the new assessment demands. The teachers were reticent in their views about how they employed approaches in their involving hands-on and mentally challenging opportunities. For instance, Ms Malane said there are not so many changes in terms of offering students more learner-centred opportunities or practical oriented lessons. She said she knew that teaching was supposed to have changed and that:

> …you can't always just teach, teach…without like doing more of experiments or demonstrations… (Malane interview, pg 4)

But due to certain factors such as

> …if you look at the syllabus it appears a bit longer … in some cases the number of periods has been reduced … you have to move faster (Malane interview, pg 2)

If it was not for the inhibiting factors, Ms Malane thought teachers would do more. Mr Kgabo also held the same view of what the curriculum demands and the practicality of using the BGCSE methodology. He said that the syllabus outlines:

> …teaching and assessment procedures…involves practical, mention application of science… (Kgabo interview, pg 2)

But he said it is '*not possible to do what we are required to do, but we try…'* (Kgabo interview, pg 2). Mr Kgabo thought that rather than following what was outlined in the syllabus only, their teaching approaches had mainly been influenced by their involvement in '*examination marking' (*Kgabo interview, pg 6).

Areas of improvement involved offering equal opportunities '*for single, double and separate (triple)' (*Kgabo interview, pg 6) due to examination demands. Though the teachers thought they were trying to structure lessons to engage students more, Ms Malane thought that their teaching had been also influenced by the syllabus and text books students use. In a case where a teacher is not confident with what depth the concept should be covered, it becomes a problem as their reference becomes knowledge gained from examination marking concerning how much learners should know. In terms of teaching, Ms Malane thought that if the objectives were more specific about teaching approaches by using words like '*demonstrate …rate of reaction... even give examples of experiment and even the types of chemicals to use…*' (Malane interview, pg 6). She thought such guidelines would be helpful.

The teachers thought that such a move would be helpful because even though the chemistry section had enough apparatus and materials, preparation was problematic because of lack of qualified laboratory assistants, bulky syllabus and the number of lessons a week each teacher had to contend with.

Summary on Interpretation of the Curriculum and its Intentions

- There was a belief by the teachers that not much has changed, if anything the quality of the curriculum has gone down. Though the teachers had not taught the old curriculum, the strong association with curriculum as content meant teachers viewed the loss of certain topics as having contributed to weakening the chemistry curriculum.
- According to the teachers, the curriculum was not limited to the content only, to a smaller extent it also included the BGCSE philosophy and its methodology
- Teachers thought the curriculum now placed a lot of value on applied chemistry and the nature of science
- Activity-based teaching and learning was mainly viewed as offering demonstrations and experiments
- Practical work in this school was viewed as important to all learners (all forms and science streams).

Changes to the curriculum in terms of practice appeared well understood in this school especially relating to how the single and double science streams should be treated, which teachers thought should not be ignored. Their views on how their teaching was supposed to have changed will now be discussed.

6.3 Implementation in the Classroom

The teachers' epistemological beliefs pertaining to hands-on and mentally engaging learning opportunities were explored further in order to further find out how the teachers' perceptions and instructional goals they mentioned above, related to their teaching actions. Classroom observation data was scrutinized to find the general implementation in classrooms. The purpose of this section is to document the practice of each teacher's:

- Approaches adopted in teaching chemistry in Domboshaba SSS
- Teacher- learner interactions and the
- Implementation of practical-work

Mr Kgabo's teaching will be explored and discussed first.

6.3.1 Lessons Given by Mr Kgabo

Mr Kgabo was interviewed once and observed teaching a form five triple and a single science class 6 times. During the interview Mr Kgabo pointed out that in the science department, teachers were aware that teaching is supposed to be done differently. He talked of the source of this knowledge as coming from the outline of the syllabus which spells out '*teaching and assessment procedures' (*Kgabo interview, pg 2) that teaching should now be more '*…practical,* (and) *mention of application of science' (*Kgabo interview, pg 2). Mr Kgabo remained modest about how much he was implementing the curriculum as intended saying, '*…it is not possible what we are required to do, but we try…'* (Kgabo interview, pg 2). Observing his two classes gave a clear picture of the types of teaching methods adopted as well as the types of interactions that occurred in the classroom.

Types of Interactions

Observation of Mr Kgabo's lessons showed a variation of teaching methods employed. There was a mixture of the lecture method, class discussions and experimental work.

Nature of Interactions in Triple Science Class

Mr Kgabo generally started most of his lessons by lecturing as shown in table 6.2. Regarding teacher-learner interaction, there was a variation as the teacher made lessons more interactive through discussions, initiated by asking learners questions during the lesson. Less thought-provoking discussion occurred when the teacher covered a topic he regarded as difficult to teach from organic chemistry. In an attempt to involve students more, Mr Kgabo chipped in with many low order questions like,

> T: Terylene contains ester linkage and so it's a ---? ---
> T: Terylene is a fibre of considerable strength. It is used in clothing, tiles and...?
> (W1D3 Kgabo pg 1)

Learners participated, filling the gaps in chorus. The teacher attempted to put the topic into context by requiring students to give examples of macro-molecules. For instance, the teacher asked students to give examples of macro molecules. Learners responded giving:

> …proteins, DNA, fats, meat, fish… (W1D3 Kgabo, pg 2).

At some point the students seemed to want to trigger discussions by raising issues the teacher probably thought were not related to the topic and so did not want to spend time on. For instance learners attempted to argue whether there was any difference between meat and fish. They gave reasons such as:

> …fish is fish… meat comes from the mammals and fish is not a mammal… with meat it can be turned into biltong…, (W1D3 Kgabo, pg 2'.

Students wanted to stir the lesson into discussion mode though the teacher cut them off. He did not attempt to link the two with proteins, or the nature of linkages he described as crucial to formation of these macro-molecules. Instead he said:

> I don't know, you have to tell me… I will make a research in the bible later' (W1D3 Kgabo, pg 2).

He did not seem to see the link with the topic at hand and also did not want to go off topic for long. Learners appeared to want to engage more at times asking questions that also exposed the level of teacher thinking and preparedness. A learner asked a question '*Aren't all pigments protein?*' (W1D3 Kgabo, pg 2), revealed the teacher was not sure of the answer, he responded

> '... you mean like during photosynthesis topic…I think you are right it could be a protein' (W1D3 Kgabo, pg 2).

He still did not link the question with topic 'macromolecules' or linkages found in pigments. A lack of engaging activities caused learners to lose interest in the topic, as they became restless and asked when the topic would be over. This caused the teacher to think it was too difficult, a learner responded and said:

> … No, it's only that it is getting boring (W1D3 Kgabo, pg 4).

Mr Kgabo was not comfortable with this topic. The teacher appeared to struggle to make the lesson more interesting to learners as he could only ask low order questions such as:

T: all enzymes are proteins, but …?
S: …not all proteins are enzymes
T: Proteins are built up by a polymerization of a monomer called ---? ---`

T: The linkage is called… (W1D3 Kgabo, pg 2)

Learners did not seem to enjoy the topic as they expressed their dislike for the topic due to lack of meaningful discussion opportunities. His limited strategies to teach this topic placed him under pressure to complete it. The teacher rushed through subtopics, as he related the concepts like hydrolysis of starch and proteins to the digestive system. Though Mr Kgabo wanted to make a point about the application of macro-molecules such as fibre in making of clothes, tiles, tyres, it did not make the students interested. He promised students more interesting topics and activities soon after the organic chemistry topic.

Minds-on and Hands-on Activities

Mr Kgabo had instances were his lessons were made hands-on or interactive through discussions. For instance, when the concept of calculating 'oxidation numbers' was introduced, the students asked a lot of questions as they seemed not to follow. Students were given classroom practice exercises to work on but showed confusion. Hence, they asked questions such as '*how do you know that certain atoms or elements have different valences'* (W3D1 Kgabo, pg 1) observed for transition and some non-metals like sulfur which generated debates. The teacher seemed to find it easier by encouraging algorithmic learning. Students were given classroom tasks to work on involving calculations such as '*find the oxidation state of S, N, and Cl in:* SO_3^{2-}*…*NO_3^- *…*$HClO_3$*…*' (W3D1 Kgabo, pg 1).

The class exercise helped to reveal misconceptions from learners, for instance when the ion 'Fe^{3+}' was said to gain electrons during reduction. Students mixed a metal and its cation as they thought a metal cannot gain an electron as in 'ionic bonding'. The strategy seemed to work well in this class as the teacher was able to identify misunderstandings.

Nature of Interactions in a Triple Science Class

Mr Kgabo used the same approach of introducing a topic through lecture and exercises method when teaching the form four students. The lecture method was accompanied by exercises that he worked together with the students, before giving individualized practice exercises. The learners had difficulties understanding the

concept of working out the formula of compounds. The lack of understanding was more pronounced when learners were using compound ions like ammonium, hydroxide, and nitrate ions. Learners came up with formulae such as '$CaOH_2$', which made the teacher think that the learners are not bright enough to be taking triple science if they struggled with such concepts. The teacher was able to identify lack of understanding which led to him reinforcing with more work. Algorithmic approaches were encouraged by the teacher as he kept referring to mark allocation for every step they use.

Mr Kgabo conducted his classes in more or less the same pattern. He introduced a topic through a lecture method that was generally interactive, through class practice exercises, followed by note writing that was dictated. Whole class discussion of the practice exercise was always done towards the end of the lesson where learners were given further exercises to work at home. In most cases, practical work followed for most of the topics taught to summarize the topics such as identification of ions and reactivity reactions. The teaching pattern seemed to be in line with what he said about trying to engage learner both in giving practical, assessing them regularly and attaching application of science as much as possible during teaching.

Summary for Mr Kgabo

Mr Kgabo varied teaching approaches but the lecture method formed an important part of his teaching. He used practical work with both single and triple science classes. Both practical work and the lecturing were always combined with discussions as the teacher attempted to give learners opportunities to participate verbally.

The lecture method was used mainly to introduce the topic, and developing the lessons. Practical activities seemed to have been introduced to confirm materials already taught. His learners seemed to struggle with difficult concepts due to the teacher mainly failing to understand the learners' questions. Though learners asked a lot of questions, he seemed not to readily understand their point of view. Hence, the feeling in most cases that the learners were not bright enough. This was specially directed to the triple science learners who he did not expect to struggle with chemistry concepts.

The lack of understanding of learners' questions, as he thought they were trivial and even the failure to engage students with thought provoking questions seem to come from under estimation of the learners that they are not bright enough. The teacher did not prepare enough to respond well to unexpected questions, or even to come up with more challenging questions. Mr Kgabo mainly preferred a situation were learners just chip in the missing word as he speaks. The major preparation seemed to have been directed at producing detailed notes, and also coming up with a lot of tasks involving calculations of oxidation numbers, derivation of formulae and equations. Algorithmic procedures were very important in his lessons.

6.3.2 Lessons Given by Ms Malane

Ms Malane was observed seven times teaching single, double and a triple science class. Like Mr Kgabo, Ms Malane used the lecture method extensively for introducing concepts. Her lecture method was very interactive and therefore allowed learners to be part of the classroom discourse. She carried out practical activities with all the classes she taught. She strongly believed that learners had to be prepared for both theory and practical examinations, hence her constant mention to learners of where to expect certain concepts in final examination. It was therefore common to hear statements such as:

> In paper 3, you must be able to draw the structure of Terylene… I saw a question like this… (W1D3 Malane, pg 2)

During the interview she talked about the need to expose all the learners to hands-on activities, as all learners have a final examination paper testing practical skills. Since she did not think that it was something that can be done all the time, this made her adopt methods that she said allowed faster movement. Like her other colleagues she combined lecturing with a lot of note writing. The notes were dictated to the learners several times a lesson. This allowed for pace and learners to move at about the same pace with her as she reads the notes out.

Types of Interactions

The lecture method used was accompanied by class exercises, it allowed learners to participate by working out problems at the board with the teachers' help and later working on more individual problems. In most of her lessons, students were very

inquisitive as they asked a lot of questions wanting to know more. Some questions showed that the students perceived the lecturing was not leading to understanding. These claims will be justified below.

Nature of Interactions in a Double Science Class

In some lessons, Ms Malane's approach to teaching left students confused. This was because she rushed the lesson to get to the point where they could do calculations. For instance, teaching stoichiometry was rushed, leaving many learners frustrated. Introducing number of moles, molar volumes, molarity and empirical formulae of compounds was purely divorced from context, preferring algorithmic learning. For instance, when introducing molar gas volumes she first gave the definition writing it on board:

> …One mole of any gas occupies a volume of 24 dm^3 at room temperature and pressure, (W1D2 Malane pg 2).

She emphasized that *'what is important to know is that 1 mol of a gas occupies 24 dm^3'* (W1D2 Malane pg 2). This statement was to prepare students for algorithmic calculations that were to follow. Students participated in various ways asking questions. Some questions appeared problematic to the teacher. For instance, a student asked her '*Do we have volume measured in kilometres?* (W1D2 Malane pg *2*). The teacher seemed to lack confidence or preparedness in teaching this topic as indicated by her response to the question. She said:

> I am not very familiar with that … but … yes we have volume measured in kilometres' (W1D2 Malane pg 2).

Without going into detail or contextualizing the topic she brought in practice questions. The algorithmic procedures seemed to give Ms Malane comfort as she was more confident with calculations. The following excerpt shows the questions she wrote on the board for learners soon after introducing the topic.

(a) Calculate the volume of CO_2 occupied by
  (i) 5 moles
  (ii) 0.04 moles

(b) How many moles of ammonia gas are in
  (i) 72 dm^3
  (ii) 6000 cm^3

(W1D2 Malane pg 2)

Learners did not have problems carrying out calculations as they plugged numbers into the expression linking number of moles to molar volumes, though they had to make conversions for some. Difficulties were faced by students when the teacher turned the equation into word problems. For instance questions such as

Hydrogen gas reacts with oxygen to produce steam…
Q1. Write a balanced chemical equation for the reaction
Q2. In the equation, what volume of hydrogen and oxygen are reacting?
Q3. What is the volume of steam produced?
Q4. If 960 dm^3 of hydrogen reacted, how much steam will be produced?
(W1D2 Malane pg 4)

Learners worked on the class task individually or in small groups. The teachers had to mediate, helping students to work out the symbolic representation of the equation. It was interesting to note that majority of students failed to symbolize steam. In this situation they could not recognize steam as water in gaseous form. Further questions related to titration experiments and molarity. Learners were provided with the formula used in carrying out concentration calculations '$M_1V_1 = M_2V_2$' (W2D4 Malane, pg 1), she said '*to find what the new concentration will be… I gave this formula…*' (W2D4 Malane, pg 1). Explanation of the formula was superficial, but she demonstrated with examples how the new concentrations following dilutions can be determined.

Making Lessons More Interactive

The lecture method, which was always mixed with discussion of problem tasks, was the most favoured approach by the Ms Malane. At times, such discussions were used as a build up to a practical activity. She seemed to have good knowledge about students' difficulties with practical work.

Practical work was not always in the form of experiments involving chemical test as she expressed in the interview. When teaching organic chemistry, she came up with an activity requiring students to use various monomers and linkages to create macro-molecules demonstration 'condensation polymerization'.

Another type of hands-on activity was organized specifically to expose learners to apparatus. This was especially true with the single and double science students who she said were never given many opportunities to have individualized practical

sessions. Ms Malane brought a number of pieces of apparatus to a double science class for learners to observe. This confirmed her talk during the interview about the importance of

> …demonstrations and practical work…In most cases you find that you really have to give the students the apparatus to use so that they see that and that, so that they can be able to answer questions, (Malane interview, pg 3)

These included a burette, pipette, volumetric flask and beakers of various sizes. Enough burettes and pipettes were brought to be shared by students in pairs. Having students view this was seen as important by the teacher as one of their final examination papers requires knowledge of apparatus and practical skills. Observation of such apparatus created a lot of excitement in learners. They held the glassware especially the burette for a long time trying to figure out how they work and how measurements are taken. Scrutinising of apparatus led further questions such as '*what is the purpose of the temperature written (such as 25 ^{o}C)…'* (W1D2 Malane pg 4) and also 'why the burette was not properly labelled'. According to the learners, they expected the 50 cm^3 mark to be at the top of the glassware and the 0 mark at the bottom. The viewing appeared a useful step as the teacher was not able to convincingly address some of the questions before she carried out a titration demonstration. The questions that concerned the labelling of the burette appeared to be addressed by the demonstration.

When demonstrating titration procedures, Ms Malane did all the handling of apparatus and solutions, carrying out the experiment four times. Learners were involved in taking readings during titration experiments and later helping to choose the best fit results for calculations. Following the experiment, the teacher gave the students more practice exercises relating to the titration practical they performed. They practiced how to pick best readings, take average, balance equations and use the supplied information to calculate the concentration of the unknown solution.

What seemed to be missing in the teachers' example was making the problems more contextualized in stoichiometry. The major context the teacher was concerned with was to relate the section of content or concept taught with types of questions to expect in the examination. For instance, learners were told that titration formed '*…an*

important section of your paper 4…' (W2D4 Malane, pg 3). Such reference came often during the organic chemistry Ms Malane telling students,

> You will not be asked to derive the structure of proteins… but most of the questions in paper 1… you might find a question having say structures to identify… you must be able to identify them. In paper 3, you must be able to draw the structure of terylene… I saw a question like this… (W1D3 Malane, pg 2)

Contextualising Chemistry

Mrs Malane seemed more confident bringing application of science when dealing with macro molecules (organic chemistry). She readily found examples such as talking about

> …plastic bags picked from shops and how problematic they too are, 'unlike banana peels which rot away... (W1D3 Malane, pg 1)

Plastic bags were mentioned as '*examples of synthetic polymers which are man made*' (W1D3 Malane, pg 1). Hydrolysis of macro molecules were linked to some of the industrial process, these links fascinated learners. For example, they were in disbelief on being made aware of how soap is produced.

T: When fats are hydrolysed with NaOH, a major product called soap is formed.
S: Soap?
T: Sesepa (soap)… then loud noise (W1D3 Malane, pg 3)

Learners never knew before how soap was made. Though very interesting to the students due to relation to reality and application of chemistry, the teacher did not take it further. The teacher also related some of the processes with topics they have covered in biology. She said:

When we talk of hydrolysis we are like talking about digestion. You've done digestion in biology, right?
T: What is the pH in the stomach?
S: 2
T: What is the acid responsible for that?
S: hydrochloric acid
T: So hydrolysis is just like digestion (W1D3 Malane, pg 2)

From the above excerpt, it could be said that students were made to link hydrolysis to various context such as soap making and digestion. Equations were given to learners showing breakdown of large molecules to monomers or by-products such as soap.

Summary for Ms Malane

Ms Malane structured her lessons such that there was teacher talk, discussions involving learners, note writing and a lot of class practice exercises. Learners were always given a chance to work on such problems individually and occasionally consulted with peers. She moved around checking on progress and mediating to those who needed her help. All class exercises were discussed by the whole class to ensure all have the correct methods of doing things.

Ms Malane was mainly concerned with algorithmic procedures. This was only true in topics requiring calculations such as stoichiometry, the teacher wanted her learners to master use of equations. Questions were not really problematised by involving context. But during teaching, the teacher was able to relate some concepts to application in real life situations. Like her colleagues, she also used practical work to summarize or introduce topics. Practical activities were mainly encouraged by the demand of paper 4 which calls for knowledge of practical related skills by all learners.

It was also observed that problem solving tasks that were organised for learners to practice calculating skills were also highly contextualised and related to reality. One weakness was that the questions were often poorly phrased.

6.3.3 Lessons Given by Mr Pula

Mr Pula was observed teaching 3 classes seven times, two double science form 5 classes and a triple science form four class. His teaching approaches resembled those of his colleagues including a variation of methods such as teacher talk, discussions and practical work. Teacher talk dominated his lessons, usually accompanied by dictating of detailed notes to learners. During an interview, Mr Pula said he believed in using teaching methods that are more engaging to learners only sporadically. He indicated that his preference was to use teacher-centred methods to teach as it allowed him to cover more content. He was mainly worried that giving too many practice exercises in a lesson consumes time needed for covering a lot of content.

> I don't do it often because it is time consuming, had I not done it today, I could have covered a lot. This syllabus is very long (W1D4 Pula, pg 6)

He was observed in different occasions using more learner-oriented teaching approaches as he gave learners text-based tasks and practical demonstrations.

Nature of Interaction in a Double Science Class

Mr Pula's lessons always started with a revision of one or two questions from the previous assignment. He encouraged his learners to participate in the lesson proceedings by sending students to the board to work on calculations such as balancing equations. But his students were generally reluctant to participate. He attributed the lack of participation by students as a result of to lack of '… *physical advice…'* (W1D2 Pula, pg 2)', which meant the administration of corporal punishment.

Though assignments formed an important part of his teaching, he found it hard to get all learners to submit. Petty excuses such as students claiming they could not find their notebooks or textbooks left the teacher frustrated as it disrupted his teaching approach. Mr Pula also thought that those who submitted usually put little effort in the work, saying '*it was as good as not having done it'* (W1D4 Pula, pg 2). The teacher thought that generally his students did not take their work seriously. He gave an example of one boy he said had never submitted any work for marking. On one occasion during the lesson he singled him out and said '*you don't want to come to school,… for lessons, why are you in here really…' (*W1D4 Pula, pg 1). Mr Pula associated this characteristic with this single science class mentality. During the interview, he described them as a '*… class of students who care less about education and tend to put more value on non- academic related things…' (*W1D4 Pula, pg 6).

Despite the lack of drive to learn, Mr Pula still attempted to engage the students in class activities. For instance, Mr Pula used some of the assignment questions to have learners participate and be involved in lessons. He usually introduced his lesson through the use of questions from the homework:

T: Now let's just look at the assignment… Nonofo (was asked to go and work it out on the board … picked a piece of chalk, and started working on the problem silently…)
T: Why are you quiet? (The teacher asked Nonofo. She was still working but on her own…)
S: One male student shouts… 'Tell us' and later again 'Nonofo, talk'. But she continues to work silently writing the following:

	C	H	O
Mass in grams	52.17	13	34.83
No of moles	/12	/1	/16
	4.34	13	2.14
Simplest ratio	2	6	1

Formula: C_2H_6O (W1D4 Pula, pg 5)

After finishing her calculation, she started to talk to the rest of the class mixing English and Setswana. Through involvement the teacher ensured that learners got to demonstrate their understanding working on the examples, communicating and at the same time preparing for final examinations.

One of the mostly problematic topics the teacher taught was formulating and balancing of equations. The teacher gave word equations such as a reaction between two substances to give new products. Here students were to first understand the context of the question, convert the word equation into formula equation, then balancing before they could make calculation of number of moles, mass or volumes. Students had many difficulties working individually. During whole class activities, when they worked with the assistance of the teacher at the board, they seemed to follow.

To try and motivate the learners, Mr Pula constantly linked their work with final examination as he kept on telling the students that if they do certain steps 'they' will be rewarded or '*…you are given one (1) mark for the effort of constructing the equation'* (W1D4 Pula, pg 2), referring the examiners.

Mr Pula's general teaching methods were building on the assignment reviews. New topics that involved calculations were briefly introduced through teacher-talk and giving note. For instance, introducing a subtopic "percentage yield and empirical formula" was done by briefly giving the definitions an approach that is against curriculum objectives. There was no linkage of the concept to context or its application in real life situation. Following the introductory exemplary task, Mr Pula said '*…straight away I am going to start with an exercise…' (*W1D4 Pula, pg 2). The teacher was not really trying to bring a holistic understanding of concept but only

algorithmic understanding. Mr Pula gave students an example below saying '*I am going to do the first part...'* (W1D4 Pula, pg 3), he demonstrated on the board the steps to be followed.

(i) Determine the empirical formula of a compound which contains 50% by mass carbon and 20% by mass hydrogen.
(ii) The molecular mass of the compound is 30. What is the molecular formula of the compound? (W1D4 Pula, pg 3)

The teacher encouraged students to ask questions, which at times led to learners responding well, bringing questions of their own such as why '*we have to start with carbon...'* (W1D4 Pula, pg 3'. It was interesting to note that though Mr Pula invited questions, some of his responses did not invite teacher-learners dialogue. For instance, a response from the teacher '*…because it has been agreed'* (W1D4 Pula, pg 3) did not convince students, hence murmurings could be heard. Though the teacher encouraged students to contribute if they didn't ask any questions, Mr Pula's way of asking questions did not invite any form of dialogue. For instance, asking students 'Do you understand…?' (W1D4 Pula, pg3) A response coming from learners saying they don't was ridiculed by the teacher as he wanted to know exactly what they don't understand. Lack of confidence by learners to ask probing questions discouraged them due to lack of constructive guidance by the teacher through reformulating their questions well. Checking students' understanding through asking appropriate questions was not his strength. To support learners more, Mr Pula favoured giving students more problem solving questions from the textbook to work individually or in small groups which he assisted.

The teacher created more participation opportunities for learners summarizing the lessons at the board. Chosen students preferred to work silently at the board resisting persuasions from peers and the teacher to talk as they work. At the end of their displays, they made brief summary of how they went through their work. The teacher also expanded on their explanations. He was generally satisfied when students were able to follow the steps saying '*most of you are doing quite well…' (*W1D4 Pula, pg 4'. Mr Pula ensured that learners continued to have more practice through regular assignments at the end of each lesson.

Nature of Interactions in a Single Science Class

Mr Pula also organized practical work during his teaching. For instance, teaching 'diffusion, preparation of salts, reactivity series' (see table 6.3). The science department at Domboshaba SSS generally thought that the single science students were more disadvantaged having to write final examinations testing for practical skills without performing one. This has led to a culture of carrying out practical activities by all classes. Mr Pula's learners were not observed carrying out practical work, but the teacher organized teacher-led demonstrations. During demonstrations the teacher preferred to carry out the experiment himself and have learners having to observe from their sitting positions or around the demonstration table. He used the Predict-Observe-Explain (POE) approach when demonstrating diffusion of solids (potassium permanganate crystals) in liquids (water).

According to psychological constructivists, these events create cognitive dissonance for learners which should help them to be ready to learn. The theory requires learners to hypothesise their hypotheses before carrying out the experiment. It is important to ask them to predict what will happen, and why they believe that. The activity can now be carried out so learners can watch and note what happens. Following the activity, learners can hypothesise about why things happened the way they did followed by a debriefing.

In Mr Pula's lesson, learner were asked to make representation diagrams of particles to show what happens from the moment crystals are deposited (using a thistle funnel) at the bottom of a beaker filled with (cold and hot) water to some time later. Students kept track of the changes till the end of the test, having to make another diagram to show how the particles of water and crystals were distributed. At the end of the experiment, students were required to draw conclusions. They had to explain their observation in relating to the particulate nature of matter guided by the questions,

———

(a) Explain your observations in terms of particles…
(c) What difference do you see between the beakers with cold and hot water?
(d) What 2 conclusions can you draw from the experiments? (W3D3 Pula, pg 3)

During practical work students were very lively. Participation involved discussions between table (group) members, trying to link observations with spread of particles.

At the end, a whole class discussion was used to sum the task. The teacher ensured that students' leave the topic with new or common knowledge. Initial responses showed students wanted to label observations and conclusions as diffusion. For instance, they said '*diffusion has occurred'* (W3D3 Pula, pg 2). Mr Pula guided the discussion saying:

> …did you see it (diffusion) occur? You must know the difference between observation and conclusion. Conclusion comes from the observation. Can I *cancel* from your answer the word diffusion? … (W3D3 Pula, pg 2)

He wanted the learners to talk about the colour in different section of the beaker, such as its intensity, its rate of spread in hot and cold water but not calling all observations diffusion. These seemed to improve the discussion by the students, as other phrases like solid particles have dissolved or mixed faster in hot water were used.

For both form-four and five classes, the teacher made sure that learners were exposed to hands-on activities even though he viewed such activities as taking too much of teaching time. All the practical activities were accompanied by questions that helped guide their observations and discussions.

6.4 Hands on Activities – Practical Work

One of the major requirements of the BGCSE curriculum was to increase the exposure students have to minds-on and hands-on activities. Due to the importance of laboratory activities' to science teaching, this section focused on the three teachers' teaching action around practical work. Practical activities were taken to include tasks requiring physical manipulation of objects or equipment. This section looked at how much students were exposed to practical activities with the view to help develop various skills.

6.4.1 Experiments Observed

A summary of the practical activities observed during the research study period was recorded in the table 6.3 below.

Table 6.3: Experiments carried out by Domboshaba SSS teachers

Teacher	Experiment	Activities (Students)
Mr Kgabo	Reactivity series (triple)	*Small group tasks* - React various metals with dilute HCl and water - Record/tabulate observation - Make conclusion about reaction rate & order of metals - Whole class discussion of results/series
	Test samples for (unknown) - cations and anions (single)	Experiment was two fold- *small groups* i test for cations using NaOH and NH_4OH: Mg^{2+}, Al^{3+}, Zn^{2+}, Fe^{3+}, Cu^{2+}… ii Test for anions: Cl^-, I^-, SO_4^{2-}, Br^-, CO_3^{2-}, - Record observations - Draw conclusions of ions present
Ms Malane	Reactivity of metals Test for gases (triple)	*Small groups* - React various metals' reactivity in dilute HCl and water - Trap and test for H_2 gas - Record/tabulate observation - Make conclusion about order of metals - Whole class discussion of results/series
	Display of apparatus Titration (single)	*Teacher demonstration* - Display apparatus for titration (for viewing and handling) - Teacher demonstrate titration (3 titres made) - Tabulate results and chose best results - Calculate concentration of unknown
	Diffusion of solids in liquids Diffusion of gases (single)	(i) *Small groups* investigate diffusion of solids in liquids, record observation (ii) Teacher demonstrates diffusion in gases (using HCl and NH_3 gases) a. Observe speed of particles in gases b. Explain the observations
Mr Pula	A display/ viewing of apparatus (quantitative analysis) – (double)	*Teacher demonstration* - Display of apparatus for viewing (volumetric flask, beaker, etc of various sizes) - Note calibrations
	Diffusion in solids in liquids (POE) (single)	*Teacher demonstration:* (POE approach) - Diffusion in liquids- $KMnO_4$ crystals deposited in: Hot and cold water - Students to predict particle distribution of solute and water - Make observations - Explain different pattern of movement of particles/colour - Make conclusions

The table gives a summary of the kind of practical activities the teachers organised during the study period. The observation data shows some variations in the number of practical sessions carried out even though the teachers were covering the same topics. Two approaches to practical activities were favoured by the teachers, in the form of a teacher led demonstration or learners led (group) experiments.

6.4.2 Common Features

Though results from the interviews did not show teachers' commitment to carrying out practical work, classroom observation showed that the three conducted practical work on regular bases. As indicated in table 6.3 above, teachers conducted more or less the same kind of experiments as they were covering the same topics. For instance, Ms Malane and Mr Pula were covering diffusion with the form 4 students. Results from the observations show that practical component in chemistry teaching often

meant different things to different teachers. For instance, though Ms Malane allowed small group activities, Mr Pula preferred teacher demonstrations, learners were only engaged mentally but did not participate hands-on.

Learners were given the opportunity to either carry out practical work or observe a practical performance by teacher irrespective of science stream. The teachers' position about giving practical work was that all learners should be exposed to experiments due to the mandatory assessment of procedural skills in the BGCSE examinations.

The types of experiments teachers carried out were closed-ended investigations. For instance, experiments involved required students to follow procedures which were clearly outlined by the teachers. Further instructions were given on what to observe or look for and at times guides on how to make recordings provided. An example of such an experiment which is representative of how the teachers conducted experiments was given by Mr Kgabo on testing and identifying unknown cation and anions in samples provided. He provided detailed steps to follow, including a table for the results. This ensured that nothing went wrong as the learners performed the tasks and recorded their work. The procedure also seemed to save time as learners knew exactly what to do in terms of the procedures, what to look for and how to record. Despite the close-ended nature of the practical work, a lot of interest was generated. Talk emanating related to the work at hand, and all learners making their own records.

Figure 6.1: Group practical work at Domboshaba SSS

The picture above shows learners testing for various ions in groups. It was common in this school for teachers to organise such learning setting.

Ms Malane and Mr Pula also organized basic investigation experiments where students were to just observe apparatus used in titration such as burette, pipette and volumetric flask. Here students were able to ask question about calibrations, labels on apparatus without performing anything rather than just to examine. Questions raised by learners included why there was a temperature ($25^{o}C$) written on a pipette and burette. Learners also asked about the calibration of a burette. In a way the setup allowed for engagement by learners which revealed problems which related to recording and taking readings from apparatus.

The teachers thought such demonstrations were good for the single and double science students who later did 'mind-experiments'. In such activities, learners perform text-based experiments, where they have to retrieve information or data from diagrams showing apparatus. Students have to show competence in taking readings, tabulating, labelling and in some cases solving or interpreting experimental data and drawing conclusions.

Teachers encouraged learners to talk as they performed the tasks in their groups and during teacher demonstrations through guiding questions. For instance, when Mr Pula demonstrated diffusion of gases he used the Predict Observe Explain (POE) strategy. He encouraged students to predict what they think will happen when potassium permanganate crystals were deposited at the base of a beaker filled with cold or hot water.

The timing of the experiments was also important, that is looking at the point at which all the tasks were introduced it appears that all the teachers followed the same pattern. All the experiments were carried out after the theory was taught first. Generally the teachers taught first and in another lesson organized the experiment. This way the teachers said they had more time to introduce the experiment, have the students perform the experiment, and allow for interactions such as the teacher assisting those who need help. Such an arrangement also allowed pooling and discussion of the results at the end of lesson.

6.4.3 Purposes of Practical Work

All the teachers concurred that conducting practical work was good for learners. Practical work was mainly seen as a side (support) method like giving class exercises and homework. It was conducted to ensure that students have another view or exposure of the content. The reasons behind use of practicals seemed to fit the categories by Pekmez et al., (2005), of characterising the purposes teachers used experimentation in his study. The categories were as follows: substantive purposes, procedural, motivational and communicative purposes. It also appeared in this school that examinations were a strong motivator for teachers to carry out practical work with their students, hence the addition of this new category in this school.

In the substantive category, Pekmez et al. (2005) described the purposes of carrying out practical work as motivated by the desire to help learners with understanding, reinforcing as well as a backing up in illustrating of facts. This seemed true when considering the time when the experiments were introduced by the teachers. The majority of the experiments were carried out following the teaching of the theory. In such a situation, carrying out an experiment was not about generating new information or introducing new concepts, it was to strengthen the knowledge already introduced. Within this category were also found those experiments which were teacher-centred. The teachers demonstrated the experiments with little help of the students. Learners were there just to observe what was happening.

Another reason for introducing practical work seemed to fit in with the development of procedural knowledge. According to Pekmez et al., (2005) procedural knowledge was about acquiring knowledge of process skills to carry out experiments. Some experiments were designed specifically for learners to manipulate apparatus and develop manipulative skills, observations, and putting results on the table. In Domboshaba SSS, these experiments seemed to be directed at perfecting skills for performing examination based experiments for triple science learners. The experiments were also designed to assist triple science students to master procedures that are necessary to carry out practical work dealing with qualitative analysis and handling techniques in titrations. Teachers were also observed on more than one occasion bringing apparatus for students to just observe, touch them without

performing any experiment for double science learners. This was mainly to help learners know names of apparatus, how they function and also how to take readings from them.

Experimental work seemed to generate a lot of excitement in all learners. Whether learners were engaged in hands-on activities such as performing group experiments, or just touching apparatus or observing the teacher performing the experiment, excitement from learners was always very high, irrespective of the science streams.

During the interview the teachers talked about the need to have learners discussing the results at the end of the experiments. This seemed to be a departmental routine they all performed following any form of practical work such as group work and teacher demonstrations. The talks seemed to be aimed at ensuring that the observations and conclusion drawn are common to all learners.

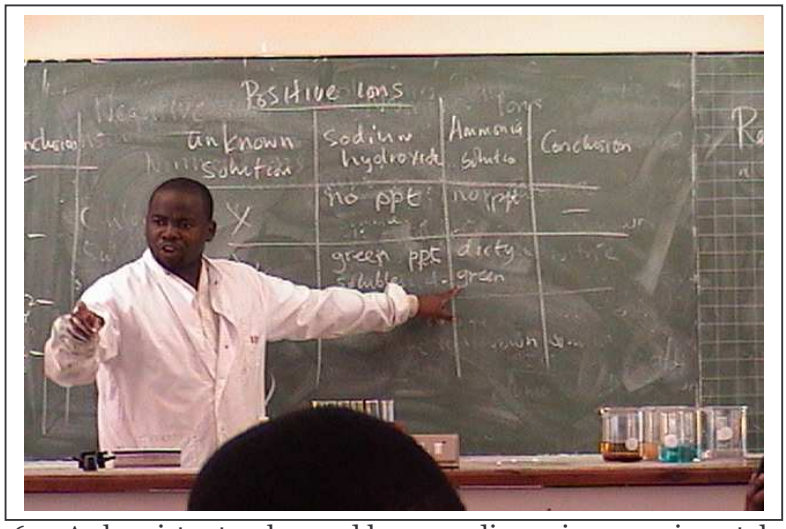


Figure 6.2: A chemistry teacher and learners discussing experimental results

The figure above shows Mr Kgabo discussing experimental results with his class after an experiment. The discussion was focused on involving learners in communication as well as ensuring that all had a common understanding at the end. Intentions for communications seemed to have changed from giving learners an opportunity to talk and express themselves in class. Teachers mainly did most of the talking even though there were instances were learners participated at the board, it was mainly to give their own results on the master table of results. There appeared to be more

communication with the triple science learners. These learners generally appeared relaxed during the experimental activities and even during the presentations.

Examinations seemed to form an important part of teaching and conducting practical work. For instance, the main reason teachers felt there was a need to carry out experiments with the single and double science learners was said to be the final examinations which were practical oriented. The triple science students have a final practical examination which involves both qualitative and quantitative components. Learners had to master the procedural skills required to do individual experiments during such activities. Teachers were also driven by examinations to consider the single and double science streams as requiring practical work. They said the fact that learners do not perform experiments and not having access to apparatus during the final examinations made them more disadvantaged. Teachers felt that the learners therefore need to be exposed to practical work so that they can get to know apparatus by their names, their uses, how to take reading from drawings such as of burettes, transfer readings to tables and even draw graphs and interpret results. According to them, as a department it has been a motivator to carryout out experiments even if at times it means learners just touching and viewing the apparatus.

6.5 Summary of Findings: Teachers and their Teaching at Domboshaba SSS

A summary of Domboshaba SSS teachers' perception of the curriculum changes and what teaching and learning meant to them is given in table 6.4 below:

Table 6.4: Domboshaba SSS teachers' perception about curriculum changes

Perception	Content changes	Assessment changes	Teaching and learning changes	Readiness to implement changes
Mr Kgabo	- New concepts and objectives added/removed - Contextualisation and application introduced	- Addition of paper 4: practical oriented - Demand for practical work - More homework	Learner-centred - Experimentation - Class exercises	-Enough resources - Poor learner background
Ms Malane	- New concepts and objectives - Contextualisation and application introduced	- Addition of paper 4-practical oriented paper Demand for practical work and homework	Learner-centred - Experimentation - Class exercises	- Enough resources - Too many classes (heavy workload)
Mr Pula	- New concepts and objectives - More content added	- Addition of paper 4: practical oriented paper - Demand for homework	- Teacher-centred methods encouraged - Tests/ assignments	- Demands not realistic - Syllabus too long - Poor learner background

The table shows the changes in curriculum the teachers considered conspicuous to them such as changes of syllabus content, assessment procedures and teaching and learning approaches. The three teachers viewed the introduction of paper 4 for the single sciences, new topics and objectives and relation of science concepts to contexts and application of science as the major changes brought by the new curriculum. Introduction of experiments and demonstrations was seen as the most obvious ways of how to deliver the BGCSE curriculum. The teachers felt they were ready to implement the prescribed changes, though priority had to go to completing the syllabus.

6.5.1 Teachers and Curriculum Change

- The teachers perceived the content as having been altered through removal of certain topics or objectives. Some new topics have been added such as recycling and energy.
- Teachers thought that currently the curriculum requires contextualization of all topics, and use of experimentation to all classes and science streams.
- Assignments were taken very seriously and were given regularly by all teachers. They claimed it formed an important part of introducing and engaging learners with content
- The bulkiness of the syllabus and not the resources was viewed as the major hindrance to engaging learners more and implementing practical work
- Implementation of practical appeared to be influenced more by the teachers' views about examination, especially paper 4. The introduction of paper 4, a practical oriented theory paper to single and double science streams had led teachers to perceive practical work as equally important to these learners who were formally neglected in terms of exposure.

6.5.2 Teachers and their Practice

Table 6.5 summarises what was actually seen to be happening in the classrooms of the three teachers observed at Domboshaba SSS. Indicators for practice included teachers' approaches, how they included contextualisation in their teaching and the manifestation of practical work in chemistry classrooms. The summary also includes learners' participation and treatment in chemistry classrooms.

Table 6.5: Domboshaba SSS teachers' teaching practice

Practice	Contextualisation and application	Teaching approach	Classroom practical work	Learner involvement/ participation	Level of preparations/ Content correctness- PCK
Mr Kgabo	- Minimal use of contexts: some relation of concepts to application of science - Most concepts divorced from context	- Teacher talk common - Detailed notes provided - Learner-centred e.g. group-work - Whole-class discussions - Regular class exercises and homework - prior knowledge search	Practical work common: - Interactive demonstrations and group experiments	- Discussions and argumentations during teaching, experiments & class discussions -Participation in experiments observed - Problem solving tasks performed at the board by learners	- Sloppy questions and use of words - Poor questioning skills - Showed under preparedness - Poor reformulation of questions - Algorithmic approach common - Teaching for examinations seemed the main aim
Ms Malane	- Varied use of contexts: use of real life examples in some topics - Some concepts divorced from contexts				
Mr Pula	- Use of context-minimal				

The table shows that generally all the teachers had similar approaches due to similarities in their philosophies concerning teaching and learning.

- Teachers occasionally used examples of application of science in some instances especially when teaching natural and synthetic macromolecules.
- The three teachers generally emphasized procedural knowledge when dealing with topics that involved calculations.
- They generally gave a lot of text-based activities, mainly involving problem solving exercises during and outside classrooms. Some of these reviews involved answering questions on work or topics just covered. This could be linked to the three teachers' involvement in marking of national examinations. They considered class exercises involving calculations very important sources of understanding how to answer questions and which would improve the pass rate.
- The same was true with the steps involved in calculations, where teachers often linked steps to marks to be gained and national examination marking standards.
- Practical activities were common amongst the observed teachers. Most of the tasks were close-ended experiments requiring learners to follow instructions provided by the teachers. Both practical and text-based activities allowed for communication during tasks and debriefing. Though learners did not have to make laboratory reports, they made drawings of some of the apparatus, set-ups and tables to record results and observations. At the end of a practical work or text-based activities, learners had to present their observations, findings or answers to the whole class with the teachers guiding the discussions.

6.6 Discussion of Findings for Domboshaba SSS

Mr Kgabo, Ms Malane and Mr Pula's practice has been explored in the above sections. Following the analysis of their practice, it was possible to predict the ZFI for the school using the guidelines from the theory of implementation by Rogan and Grayson (2003). To achieve this, each teacher's current level of operation in terms of classroom interactions, practical work and contextualization of chemistry implementation was first determined. Classroom interactions included teaching patterns as well as assessment components attached during teaching.

6.6.1 The Practice

The practice of Mr Kgabo, Ms Malane and Mr Pula at the time of the study is summarised in the table below according to the three dimensions, classroom interactions, practical work and contextualisation by Rogan and Grayson (2003).

Table 6.6: The Operational Indicators of Domboshaba SSS Teachers

Name	**Some Indicators**		
	Classroom Interactions	**Practical Work**	**Contextualisation**
Mr Kgabo	Interactive teacher-talk Low-order questions raised Teachers not too critical of learners' questions- usually ignored as trivial Detailed notes provided- dictated Homework given regularly Monthly tests given Minds-on activities and Learners engagement	Minds-on activities and Learners engagement: Practical work (interactive group work) Challenging practical activities Demonstrations (interactive: Teacher-learner talks) Highly engaging discussions reviewing practical work and demonstrations	Minimal use of examples and application from everyday life Some problem solving exercises/tasks linked to application of science BGCSE final examinations were biggest context
Ms Malane	- Class discussions (low order) Practical work (interactive group work) Challenging practical activities Demonstrations (interactive: Teacher-learners) Meaningful problem solving tasks (algorithmic teaching supported)	Practical work and demonstrations- both streams Highly engaging discussions reviewing practical work and demonstrations Qualitative & quantitative aspects Highly engaging discussions reviewing practical work and demonstrations	Teacher used examples and application from everyday life in some topics Problem solving exercises/tasks linked to application of science BGCSE final examinations were biggest context
Mr Pula	Chalk-and-talk dominated lessons Detailed notes provided Teaching oriented towards algorithmic learning Engaging questions raised during discussions Minimal hands-on and minds-on engagement	Demonstrations practical activity Interactive through POE approach Meaningful and deep engaging questions	Minimal application of science and linkage to real life BGCSE final examinations were biggest context

The table shows the indicators that made up teaching patterns for the three teachers. There was a general overlap in some of the teaching patterns observed for the teachers. For instance, Mr Kgabo and Ms Malane were very similar in their classroom interactions. Hence, their indicators for classroom interactions were combined.

6.6.2 Transforming Indicators to Operational Levels

From the indicators of practice it was possible to deduce the levels of operation using the adapted guidelines from Rogan and Grayson (2003). This involved cross-checking indicators from practice (table 6.6) against indicators found in the template (Appendices A and C). It was possible to identify indicators signalling the highest operational level. Low order indicators were also identified as they demonstrate practice at the lower operational levels. Their identification was useful as gaps within and between levels signals the range of ZFI and the depth of intervention. An example of how the cross checking was done will be demonstrated using Mr Kgabo's profile above. An attempt was made to isolate indicators according to the levels of operation as indicated in table 6.7 below.

Table 6.7: Matching practice indicators and those from Rogan and Grayson

	Level 1	**Level 2**	**Level 3 – Incomplete level**
Classroom Interactions - from practice	**Classroom Interactions** *Signs of poor preparations-* Low-order questions raised during lessons (poor questions; poor responses) Teacher not too critical of learners' questions- ignored as trivial Interactive teacher talks Detailed notes provided - dictated Homework given regularly & monthly tests given	Minds-on activities and Learners engagement: Class discussions (low order) Practical work (interactive group-work) Challenging practical activities Demonstrations (interactive: teacher-learners) Meaningful problem solving tasks-algorithmic teaching supported	Some probing of prior knowledge Some degree of minds-on learning activities (especially during demos and experiments) **Lacking: (teachers/learners)** Making of own notes Making concepts relevant Construction of knowledge Nature of scientific knowledge Challenging questions
Features from Rogan and Grayson (2003)	**Teacher:** Content presentation Well sequenced, organised, correct Sufficient provision of notes Learners engaged in questions **Learners:** Stay engaged and attentive Initiate questions Respond to questions	**Teacher:** Use of other resources during teaching Some in-depth questions Some challenging activities – meaningful group-work **Learners:** Use varied sources of information Engage in meaningful activities Make own notes from activities	**Teacher:** ***Prior learning probing and good practice –*** Construction of knowledge Relevance and problem solving Nature of scientific knowledge introduced **Learners:** Engagement in minds-on activities Make own notes during activities

Matching the teacher's practice with the template in the above example pointed to a level between 2 and 3 as the highest level of operation. This is so because though the teacher was well anchored on level 2, there were some aspects of level 3 evident in his practice but was not yet fully at level 3. It could be said Mr Kgabo was definitely

above level 2. According to the adapted operational levels, he was operating at level 2.5 on Classroom Interactions.

The same procedure was repeated to deduce the operational level in practical work and contextualisation. Features from the Rogan and Grayson (2003) were included to clarify how the two were matched.

Table 6.8: Matching other practice indicators and those from Rogan & Grayson

Level	**Practice –Science Practical Work**	***Features from Rogan and Grayson (2003)***	**Contextualisation**	***Features from Rogan and Grayson (2003***
1	All streams perform practical work and demonstrations activities	Teacher: Use demonstrations Use locally available material to illustrate lesson **Learners:** Mainly just observers	Minimal use of examples and application from everyday life	Teacher: Uses examples from everyday life Uses applications to illustrate scientific concepts **Learners:** Ask questions about science in context of everyday life
2	Demonstrations (interactive: Teacher-learner talks) Some form of planning done by the teacher	**Teachers:** Use Demonstration- promote some form of investigation **Learners:** Learners assist in planning & performing demonstrations Participate in closed practicals Communicate data using graphs and tables	Some problem solving exercises/tasks linked to application of science: BGCSE final examinations were biggest context	**Teachers:** Bases a lesson on a specific problem or issue faced by local community **Learners:** Explore explanation of scientific phenomena
3	Minds-on activities & learners engagement: Practical-work (interactive group-work) - Challenging tasks Highly engaging discussions reviewing practical and demonstrations tasks ***- Lacking: (teachers/learners)*** *- Guided discovery type of practical work* *- Learners planning and designing practical work* *- Learners writing scientific reports & justifying their conclusions* *- Challenging questions*	**Teacher:** Designs practical work Encourages learner discovery of information **Learners:** Perform guided discovery type of practical work Work in small groups Engage in hands-on activities Write scientific reports based on data colleted	***Lacking: (teachers/learners)*** *- Actively investigating application of science and technology in own environment* *- Learners writing scientific reports & justifying their conclusions* *- Challenging questions*	**Teacher:** Facilitate learner activities **Learners:** Actively investigate application of science & technology in their own environment Mainly use data gathering methods such as surveys

A look at the practical work component indicates that operation in terms of science practical work was between levels 2 and 3. There were certain crucial aspects of level 3 that were missing (indicated in the table above), which made it down grade the level from 3 to level 2.5. The same procedure was repeated for all the three teachers on the three dimensions. The identified highest levels of operation were entered in the table 6.9 below.

Table 6.9: The Teachers' Operational Level at Domboshaba SSS

Names	CI	PW	Contextualisation
Mr Kgabo	2.5	2.5	2
Ms Malane	2.5	2.5	2
Mr Pula	2	2.5	2
Average	2.5	2.5	2

The table shows the levels of operation for the three teachers in the three dimensions classroom interactions, science practical work and contextualisation.

Calculating Domboshaba SSS Operational Level

To arrive at the operational level for the school, the average of the three teachers was found. The school's operational level did not take into consideration the lowest and highest operational levels of the teachers. For instance, the lowest operation in terms of classroom interactions was 2 whilst the highest was 2.5. In this case the operational level for Domboshaba SSS was considered as 2.5.

It is possible that such an average would not portray the school well, as the finer details of teachers differ. A closer look at the average value and what was happening on the ground seemed acceptable though as the obtained values seemed to tie with the department's practices generally found. Level 2 has been discussed above as mainly activities that are dominated by the teacher. For instance, the sequencing, presentation of the lesson and note provision is guided by the teacher. More in-depth components such as the questions posed in the lessons have not reached level 3 yet. Level 3 consists of more minds-on activities and learners taking the centre-stage in their learning. At higher levels, chemistry learning is not entirely focused on content only but the processes of science become important also.

According to the findings, level 2.5 characterises flashes of good practice where learners are beginning to take centre-stage in some areas, for instance in hands-on and communicative activities. All the teachers seemed to have been operating just higher than level 2, hence the school's level had been identified in this regard.

To make the results concerning the teachers and the school's practices more readable, a bar-graph was used to aid visualisation. The graph also gives zones immediately after the highest operation level which is called the ZFI. It is through indicators within

the ZFI that areas that need improvement for each teacher and school can be identified and be a target for intervention.

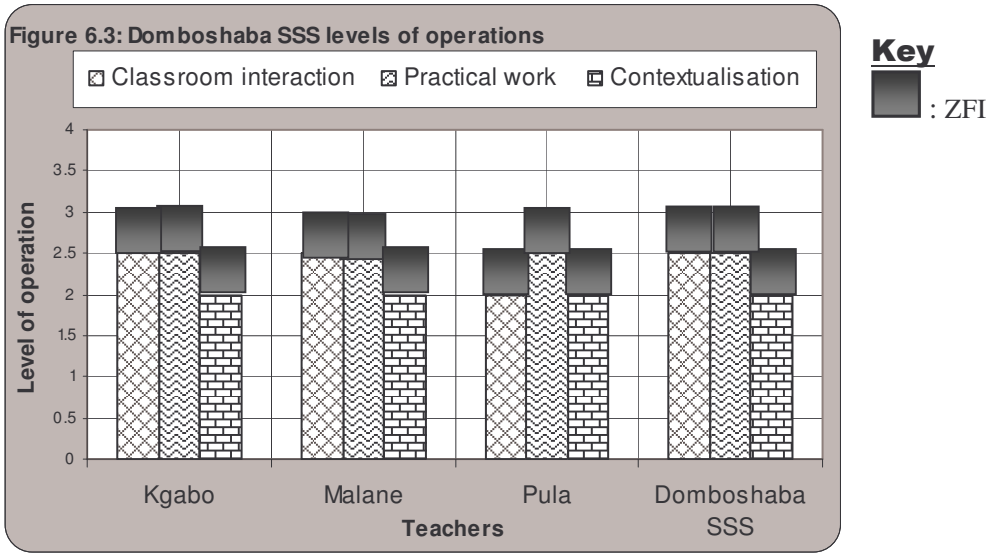


Figure 6.3: Domboshaba SSS' levels of operations

The graphs show that the teachers were operating at more or less the same level. The same patterns of operations in this school did indeed mean the teachers generally had similar strengths and weaknesses. This had various implications for the teachers in this school as they were guided by more or less the same philosophy of the department. All the three teachers strongly believed that their involvement in the marking of examination had made them raise their teaching standards through quality marking and preparing students for examinations. Teachers often dissected tests, assignments or lesson exercises to show mark allocation or importance of certain steps in their mainly calculation or derivation tasks. A practical examination paper, (paper 4) was seen as the main reason for the need to now give practical activities to single and double science learners. This has helped all chemistry teachers in the department to offer hands-on activities in the form of practice exercises, and more practical work for most of the topics they teach. All the teachers seemed geared towards preparing learners for the ultimate goal of passing the examinations.

Apart from practical work, classroom interactions engaged learners in answering low order questions, taking part in classroom exercises. The teachers at times appeared

unsure how to respond to questions concerning certain concepts. Though chemistry content knowledge was not in doubt, this could be associated with lack of in-depth preparation, with their belief that learners were not inquisitive enough. Curious learners were perceived as those who could ask interesting or challenging questions, without the teacher challenging them to answer such questions.

Limited use of day-to-day examples and analogies confirmed level 2.5 in teaching aspects concerning science and society and classroom interactions.

6.6.3 Discussing Domboshaba SSS Operational Levels

The levels of operation of the teachers had been used to come up with a composite operational level of Domboshaba SSS (fig. 6.3). Teachers generally operated at moderate levels 2.5, 2.5 and 2 in terms of classroom interactions, practical work, and incorporating contexts when teaching.

The teachers' practice was characterised by flashes of classroom interactions that were interactive and participatory to learners. But the type of questions involved did not always lead to quality talks. For instance, there were often low-order questions asked by Mr Kgabo and also a lack of critical insights from all the teachers following learners' questions and comments. Despite the low order questions and talk in classrooms, there was a lot of practical work carried out by all the teachers for all the science streams. These showed that the teachers were committed to providing all learners with the same kind of teaching and learning opportunities. Figure 6.3 above seems to prove this, shown by same intensity on the operational scale.

The result has several implications in terms of whether teaching and learning can be considered as learner-centred in this school, equitable and balanced to all chemistry learners. From the identified ZFI, several deductions can be made concerning classroom interactions, contextualisation and chemistry practical work.

Implications of Learner-Centred Teaching and Learning

From the graph, it could be deduced that regarding teachers at this school as to whether their teaching of the chemistry curriculum was guided by the BGCSE

methodology, there was indeed a shift towards more activity-based learning and learner-oriented talks by the three teachers. Shifts were more apparent where the teachers mainly used hands-on activities such as written tasks, demonstrations and practical work to support theory learnt in class which could be regarded as level 3 in classroom interactions.

The weakness found in their classroom teaching patterns was that the notion of prior knowledge of concepts taught was never of interest and investigative practical work was never considered. Practical work was also never linked to context, for instance qualitative work related to diagnostic tests followed in forensic investigations. Practical work could also have been made more meaningful by giving learners more time during discussions so that they can have well reasoned responses instead of just filling up tables or providing observations without much reasoning as to why that was the case. Time seemed the issue in this regard. The teachers generally preferred direct talks so that time could be saved. Though teachers believed that the curriculum requires learner engagement, contextualising concepts and more practical work it was clear that there were still some aspects of the curriculum that were not yet well mastered by teachers.

Even though teachers thought they could move to a higher 'gear' when the negative factors were removed, their limited PCK seemed to constrain them to effectively benefit learners. Limitations were observed in terms of teachers' readiness to reformulate learners' questions, ask thought provoking questions, flexibility with strategies to unpack or deliver concepts through various representations and the nature of talks that went on following practical work. It could be said that though they involved learners in hands-on activities, minds-on activities seemed to be lagging behind. Questions used were not well thought out, prior knowledge was not sought in most cases, algorithmic learning was encouraged. These seemed to show that though teachers had the right knowledge of content, they were still limited in terms of improving their patterns of verbal interactions.

It was clear from the types of teaching formats that one of the most influential factors in implementation was the examinations. Examinations drove practical work, the monthly tests, and the frequent home work exercises. The teachers found it easier to

adopt these activities and still boost learners' chances of performing better in the final examinations. The least recognised factors were the resources found in the chemistry section. Teachers did not mention resources as affecting teaching chemistry. This was mainly due to the fact that most of the material needed for teaching was available in the department.

Areas that needed improvements seemed to be related with the depth of engagement. The confidence level of learners compounded by time shortages meant teachers could not involve learners in high level discussions. Practical work as described above was not made investigative in nature. Most practical work was made to act as follow up to the theory already learnt. Though the teachers did not appear limited by chemistry content knowledge as all of them had university degrees in science/chemistry education, it was evident that the three teachers were limited in the way they contextualised knowledge and made the practical work more investigative, as well as being critical enough to explore learners' questions without labelling them as trivial. Teachers appeared to be limited in unpacking certain concepts and learners' questions to improve debates in class, and even issues learners found difficult. For instance, the three teachers appeared to struggle to introduce empirical formulae and stoichiometry concepts. They failed to find suitable examples to link with application of science, analogies to make concepts more vivid and understandable to learners.

When introducing these concepts, the teachers merely defined concepts like 'molar gas volumes and molarity' and quickly took refuge in calculations, giving many exercise questions, followed by more questions as home work. It was clear that algorithmic learning was encouraged. This appeared to point to the undeveloped PCK for the three teachers on these topics as the problematic areas.

Chapter Conclusion

All these issues have implications on the type and nature of professional development that is needed for this school. The challenge for this school is to improve on the areas they are already operating at. Apart from the resources made available and their own limitations, teachers blamed the background of learners for limiting learning. Issues cited as limiting the way they work, which could be equated to areas they felt a little out of reach included:

- having practical work that is more learner-oriented and more investigative
- improving
    - learner engagement,
    - nature of questions asked by teachers,
    - preparations for lessons
- versatility in contextualising lessons
- learning for understanding (relational learning)

CHAPTER 7 TAGALA SSS

Introduction

This chapter will once again use interview data to outline teachers' perceptions about the nature of curriculum change and demands of the curriculum, after which the general classroom activities of each of the teachers will be described. Because of the emphasis of the new curriculum on practical work, this will be discussed separately from the normal teaching. Finally the chapter will summarise what the status of Tagala SSS was in terms of Rogan and Grayson's (2003) theory of curriculum implementation and endeavour to ascertain what the ZFI for Tagala SSS was at the time of the study.

The teachers involved in the study will first be profiled.

7.1 Teachers' Profile

The biographical information concerning the two teachers and their classes from which interviews and observation data was gathered has been shown in table 7.1, but is briefly repeated for convenience.

Table 7.1: A summary of the chemistry teachers' pedagogical profiles

	Tagala SSS	
Pedagogical approaches	Mano	Mokone
Lecture method	7	6
Whole class discussion	2	4
Group discussion	2	1
Experimentation (teacher demo)	2	1
Experimentation (Learner)	3	-
Learner Presentations	-	-

In general the Tagala SSS science department and especially the chemistry section was a very young department of relatively inexperienced teachers. Of the five chemistry teachers, three had only between 6 months to 18 months of teaching experience. Mr Mano and Mr Mokone who were involved in this study fell into this category. The two most experienced teachers in the section had been in the field between four and six years. As indicated in chapter 5, this seemed to be a disjointed department, with chemistry teachers especially lacking cohesion. This made it interesting to find how they were coping and implementing the chemistry curriculum

inside the classrooms. First it was important to find how the teachers interpreted the new BGCSE curriculum and what implementation meant to them.

7.2 Teachers' Perceptions about the Curriculum Changes

Changes to the curriculum were viewed as either changes in terms of content, changes in terms of assessment or finally changes in terms of teaching and learning. Each of these areas will be explored further and later related to the impact it had on teaching of chemistry in the school.

7.2.1 Curriculum Changes in Terms of Syllabus

The two chemistry teachers involved in this study, Mr Mano and Mr Mokone, had still been on pre-service training when the new BGCSE curriculum was introduced, so had little experience of the previous curriculum. In spite of this, they were able to reflect back to their experiences when they were in senior secondary school to talk about how the curriculum had changed. Mr Mokone said about the changes:

> ...Comparing it to my time (as a school learner)… I say it has changed a lot.... Currently we are applying a new system of science double, pure and then single award. So it has changed a lot, the way topics evolved, some of them are out, some of the new ones are in (Mokone interview, pg 1).

Though the teachers saw major changes in the curriculum structures, they did not think these had been positive changes. For instance, Mr Mano talked about the removal of topics as having led to lowering the conceptual demands learners were supposed to be exposed to as the '*scope is now only limited' (*Mano interview, pg 1). He blamed this on what he called the cut and paste approach adopted by the curriculum planners in coming up with the new BGCSE syllabus. He continued:

> You will realize that in one aspect they cut out an objective and in the next topic were you need to use the objective that was cut out is the first thing, you need… so its either you teach it there or you start teaching it when you are doing the second thing (Mano interview, pg 1).

According to the teachers, the scope of the new syllabus was determined by the examinations. The old curriculum still remained a powerful reference point to them. The teachers viewed the old curriculum as possessing topics or learning objectives that should not be abandoned:

> …like normally in chemistry they are topics which are rarely covered, only because the curriculum just don't consider them… teachers go and scheme on these ones and make some handouts on them… and it was said everyone takes something… like one took sulphur and another one nitrogen, and I took water…some take… most of them are from the energy topics (Mokone interview, pg 8)

It could be concluded here that according to the teachers the new curriculum omitted important topics which had been in the old curriculum. The departmental approach to this problem was to teach these topics in any case, which resulted in a bulky chemistry syllabus.

Mr Mokone talked about the difficulties teachers generally faced in putting learner-oriented teaching into place saying, *'…you can't implement those because of time restriction' (*Mokone interview, pg 3). It could be viewed as strange that a teacher was willing to include extra topics into a curriculum while there was such an obvious problem with time. Mr Mano said about the BGCSE methodologies:

> … it's a learner-based approach, but we have to consider some of the things like the time, if you have the time, maybe you can do it (Mano interview, pg 2).

The two teachers did not immediately see increasing the number of topics as having implications for teaching approaches.

Another area where teachers saw changes concerned the assessment approaches.

7.2.2 Curriculum Change in Terms of Assessment

Concerning assessment, Mr Mano based his knowledge on the BGCSE examination format saying '*your scope is not only limited by the syllabus it's also limited by the questions'* (Mano interview, pg 1). Examinations underpinned the way teachers' taught the new curriculum because:

> …if you can look at final BGCSE papers for single and double, they are usually the same with just an addition of a few questions to make up to the extra marks for the double. But they are the same, same question and same objectives…and the question that I always ask myself is do they set for double and then subtract questions for single, or do they set for single and then add questions for double? (Mano interview, pg 1)

Different forms of assessment were seen by the teachers to be mainly different examination questions, which could come from any part of the syllabus. There was also a belief that any changes in assessment had been to make it easier for learners to pass. Mr Mano thought that during the era of the old curriculum, learners used to struggle to pass. His view was:

> …the grading system was… now relaxed…you realise that now they have got much better marks. That's the only thing that I only get to realise in the grading system.... (Mano interview, Pg 3)

The two teachers generally did not have a holistic view of what the intentions of the curriculum planners had been in making the changes. For them changes were mainly associated with question format or structures. This was endorsed by Mr Mokone, who explained how his teaching had been influenced by the new curriculum:

> I prefer to give learners class exercises, were they do it and I go around and seeing how these one is answering it…I really give them assignments. (Mokone interview, pg 3)

Changes to the curriculum in terms of practice appeared one of the less recognized changes, which teachers thought could be ignored. Their views on how their teaching was supposed to have changed will now be discussed.

7.2.3 Curriculum Changes in Terms of Teaching Practice

Concerning teaching and learning, Mr Mano and Mr Mokone seemed to be aware that the new curriculum was intended to have a different focus, with Mr Mano saying '*it's a learner-based approach…'* (Mano interview, pg 2). Mr Mokone too thought that teachers had more responsibilities in their teaching because:

> …these days the curriculum stresses serious skills for us to look on when you do pupil-based work or practical… (Mokone interview, pg 6)

Concerning their knowledge of the teaching and learning methods required to successfully implement the new curriculum, Mr Mano said, '*No… I don't think I have problems with those things*' (Mano interview, pg 2). On the other hand, Mr Mokone did not think he had all the knowledge and skills needed to teach the new curriculum as it was intended to be taught. He said:

> …of course sometimes, I would say in terms of structuring, currently I am average, the biggest problem is that well, I am fighting time you see, (Mokone interview, pg 2)

Teachers said that how they implemented and interpreted the curriculum was influenced mainly by the content in the syllabus, what appeared in the examinations and time factors. Mr Mano also said about the knowledge base he used for implementing and interpreting the BGCSE intentions:

> …I think it goes back to say as a teacher… when you were still a learner yourself, you try and bring these things together you know and try and use one that is best for the learners… (Mano interview, pg 2)

The two teachers mentioned that the new curriculum required that teaching and learning should be learner-oriented. They gave the impression that in their department there nonetheless was a trend towards following more traditional teaching approaches '*otherwise I would have maybe seen something different, or seen a difference in their ways of operations' (*Mokone interview, pg 5. The teachers seemed to feel strongly that moving towards learner-centred teaching and learning was a no go area for them, due to limitations such as the bulky syllabus, already mentioned, '*you can't implement those because of time… restrictions' (*Mokone interview, pg 3).

The findings above were based on teachers' opinions. Data from classroom observations were now scrutinized to find out how the implementation was occurring in the two teachers' chemistry classrooms.

7.3 Implementation of the New Curriculum in Chemistry Classrooms

The second part of this chapter uses lesson observations to investigate opportunities learners got to learn chemistry and doing chemistry hands-on in Tagala SSS. It was important to find classroom features to complement or contradict findings from the interviews. One of the aims of introducing the new curriculum had been to improve learning through learners' involvement in their own learning. Thus the section describes how teachers were able to vary their styles of teaching, taking the requirements of the new curriculum into account using photographs as an additional data source.

First the interactions occurring in Mr Mano's classes, a form 5 single class and a form 4 triple science class will be examined.

7.3.1 Lessons Given by Mr Mano

It has been established that Mr Mano was one of the least experienced chemistry teachers in the department and that he was aware of his deficiencies.

Going into Mr Mano's classrooms gave a clearer picture about the type of methodologies he used. Mr Mano's teaching approaches included lecturing, as well as giving hands-on activities such as practical work. The most dominant teaching process in his classes was the so-called lecture method. Whole-class discussion, group-work and practical work activities were also used occasionally to engage learners. The lecture method, which mainly involved teacher dominated talk which was the most favoured approach, was used mainly when introducing lessons. During lecturing, the Mr Mano attempted to involve learners through questions, thereby making the approach not purely teacher-centred.

Nature of Interactions in a Single Science Stream

It was interesting to find that the form 5 single science class was unwilling to participate during normal lessons. When they resisted participation, Mr Mano rebuked them, saying that they would fail. Learners in the single science stream seemed to prefer sitting quietly and making minimal contributions in class.

The learners' behaviour was remarkably different when they were observed performing experiments. They performed three experiments, one each on the factors affecting rates of reactions (temperature, concentration and surface area effects). Learners rotated between the experimental set ups, appearing very lively and interested in learning. The picture below shows a group of 4 learners working on the effects of temperature on rates of reactions. Learners moved between groups to consult with their peers and contrary to what I had observed in the classroom, they did not appear docile at all. Groups were talking and consulting freely with each other.

Figure 7.1: Single science learners performing an experiment in Tagala SSS

The teacher moved between groups assisting learners where necessary. The learners involved with the experiment requiring collection of liberated gas to measure rate of reaction, seemed to require most help as they appeared to struggle more. At the end of the practical session, when results were pooled and discussed, learners participated freely, responding to questions asked by the teacher.

Learners' pooled results obtained in their three experiments and the nature of question asked are as shown below:

Temperature, ^{o}C	**Concentration**	**Surface Area,**
RT: 1min 56sec	0.5M: 18 min 29 sec	Foil: 3min 57sec
30: 51sec	1.0M: 1min 13sec	Powder: 27sec
50: 39 sec	1.5M: 39 sec	
80: 34 sec	2.0M: 19 sec	

T: Looking at this, which has the fastest reaction?
S: 80 ^{o}C
T: remember we said the higher the conc. the higher the…
S: reaction rate
T: Those who did the foil how many minutes did it take to collect 50cm^{3} gas …
S: (Brief response from learner)
T: …remember we talked about surface area we said the higher the surface area, the higher the rate. We said powder has large surface area, the shorter the reaction time and the faster the rate of reaction. (W1D5 Mano, pg 3)

It was clear that during discussion of the three experiments they performed, learners were generally asked more questions and participated more than they had in lecture sessions. For instance, the same learners who were so highly involved in the experiments, had appeared to lack energy in class. It can be speculated that learners could have been discouraged by the pace set by the teacher. The teacher had appeared fast in introducing concepts leaving learners behind. For instance, the topic redox

reactions appeared a difficult topic for Mr Mano to teach as he rushed the definition. Before learners could grasp the fundamental concepts, he introduced examples concerning calculations, without attempting to use methods such as analogies to make the topic more understandable.

Mr Mano did not seem to take teaching the form five single class seriously. For instance, I saw one occasion when Mr Mano who had given learners some notes to copy, went to the preparation room to chat with colleagues. A female learner had been instructed to copy the notes on to the board, whilst the rest of the class copied what she had written into their notebooks.

Nature of Interactions in a Triple Science Stream

Teaching form 4 triple science class seemed to make Mr Mano more active in his teaching than he had been in the single science class. For instance, learners in the triple science class talked more during the lesson. The teacher asked more questions and the learners responded and asked questions.

Classroom observations showed that the teacher used more or less the same teaching approaches in the triple science class as he had in the single science class, but the triple science learners were much more active. The higher level of engagement seemed to be a result of the high level of curiosity among the majority of learners in the triple science class. This encouraged the teacher to ask more questions. Though many questions were posed by Mr Mano, they were mainly low-order questions and did not seem to challenge learners much, causing them to respond in chorus. A typical example of the way Mr Mano structured most of his questions was when he described the composition of an atom:

T: …that means they are how many electrons?'
S: 8e-s
T: first shell?
S: 2
T: Because it can hold how many?
S: 2
T: second one can hold how many?
S: 8
(W2D2 Mano, pg 2)

Mr Mano's lessons were also dominated by questions requiring learners to fill the gaps. For instance,

T: We also talked about the trend; as we go down, of those …**?**..
S: Decrease as we go down, (W3D3 Mano, pg 2)

Learners seemed to follow the algorithmic procedures as they said all the answers correctly in chorus. His teaching modes were mainly oriented towards algorithmic learning as shown by lack of detailed explanations, with Mr Mano preferring to give calculations instead. For instance, when attempting to explain the atomic weight and charge, he seemed to encourage rote learning because he was unable to find other ways of explaining the concepts. He said those numbers were "God given":

'…but in atomic terms we can talk of relative…some of these things… its like were you just say 'morena a realo' (God has said so).

Sub particle	**Hydrogen mass**	**H charge**
Proton	1	+
e-s	1/1840	-
Neutron	1	0

(W2D2 Mano, pg 3)

Learners appeared to struggle with the ideas and continued to make mistakes due to the low level of understanding encouraged by Mr Mano. There was some evidence that many learners were not convinced that being able to apply a rule was enough for them. They wanted more examples so they could practice the use of the rule. The teacher seemed to equate mastery of algorithmic procedures with learning (relational understanding). After giving more practice work, like working on further examples involving drawing atoms of elements of atomic numbers 7 to 12, the teacher checked learners' progress and marked their work. He said he was happy with the results of his teaching, saying '*so far… I am happy with progress made* (W2D2 Mano, pg 3)'

Lack of understanding was revealed after the learners had written a test on the topic they had covered. According to the Mr Mano, the majority of learners in the triple science class had failed. The poor performance seemed to show that the low order engagement used by Mr Mano was not enough to cognitively challenge learners to expand their thinking. The high failure rate prompted the teacher to perform an experiment on diffusion of ammonium chloride and hydrogen chloride gases. The theory on diffusion had previously been covered, but learners had failed to apply the

concept in a new situation involving two different gases, sulphur dioxide and hydrogen sulphide. By doing this the teacher unconsciously admitted that there had been something missing in his earlier teaching approach.

However, Mr Mano did not overtly associate the high failure rate with his methods of teaching. The blame was placed mainly on learners and he commented that learners were not serious. Identifying their lack of seriousness made him say how he intended improve attitudes. He said '*I am watching you… I am watching but should the problem* (of failing) *continue, I will do something about it*' (W3D3 Mano pg 1). Other threats included statements like:

> If you get anything less, I know that you are playing and I will ***hit*** you, If you cannot increase those 40s, then I know that you are playing or you are in a wrong place… (W3D3 Mano, pg 2)

Summary for Mr Mano

In the single science class, there was less commitment from both the learners to do well and the teacher. The learners were constantly rebuked and told they were destined for failure. The triple science learners on the other hand were highly committed to learning and the teacher was prepared to give a bit more after the poor performance in the test. Poor performance appeared to result from poor teaching, rather than from learners' lack of seriousness.

In both streams, the teacher

- Did not adequately explain concepts and encouraged algorithmic (instrumental) approaches to calculations.
- Failed to use questions to target deeper thinking, using the questions to help learners stay active and motivated. This was always the case, even during experimentation.
- Never contextualized concepts taught. Uses of analogies, real life examples or application of science examples were infrequent and when an analogy was used, it was not clear if it cleared misunderstanding
- Used threats of punishment to make learners work harder, even using corporal punishment in class.

7.3.2 Lessons Given by Mr Mokone

Mr Mokone was observed nine times teaching a single (form 5) and two double (form 4 and 5) science classes. Teaching using a lecturing style was found to be his preferred mode. Lecturing was usually accompanied by other activities such as class exercises, discussion and occasionally experiments making the mode more interactive than a regular lecture. Homework exercises and note writing also formed an important part of his teaching.

During the interview Mr Mokone said that changes in curriculum had been in the structure of the BGCSE, with the division into single, double and the triple sciences. He also said, that teaching was supposed to be more practical oriented, but thought being a new teacher he had not had much exposure to ways of varying teaching methods. Pedagogical features of the lessons by Mr Mokone will now be considered.

Nature of Interaction in a Double Science Class

A typical lesson by Mr Mokone started with a review of the previous topic covered, note- writing, in-class exercises and giving of home work. Review questions, usually related to the previous homework, were used to introduce lessons and direct the learners' discussions. Mr Mokone's questions were generally thought provoking, requiring prior knowledge concerning the covered topics, or calling on learners' general knowledge about the topic or concepts. For instance when the teacher covered diffusion of solids in liquids, examples used related to a commonly consumed colourful powdered drink called 'sweet-aid' which they said is a solid that dissolves in water.

The teacher also told the class about a response he had received from another form five single science class where, it was claimed: '*water particles dissolved in copper sulphate'* (W1D3 Mokone, pg 2). In this way, a misconception he had encountered in another class helped Mr Mokone to emphasis the role played by the particles of the two substances (liquid and solid) saying,

T: tell me what dissolves, water or solid?
S: sweet aid particles (in chorus) (W1D2 Mokone, pg 2)

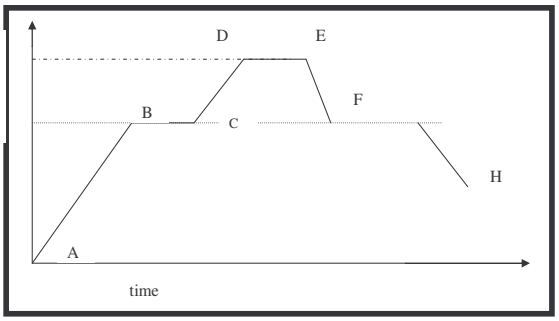
The teacher reinforced the concepts through the use of a demonstration to show the movement of $KMnO_4$ particles in water illustrated by the spreading colour. The teacher generally used analogies and misconceptions he had previously encountered. For instance in attempting to emphasize the point that particles in solids move much slower compared to gas particles, he gave an analogy that seemed to clarify the behaviour of particles at macro-level. He said:

> …particles in liquids are much compact… if you run in a forest its more difficult to run than in an open space as there are (hindrances)… That's the case in liquids than gases (W1D3 Mokone, pg 3)

Though the analogy was relevant, the teacher did not fully utilize it as he ignored reactions from learners for example that particles move faster in gases '*because they are heavier*' (W1D3 Mokone, pg 3)'. The teacher did not attempt to link the macroscopic observation of colours spreading with microscopic arrangement of particles in solutions. But generally, the teacher involved learners at various stages of the lesson, using different questions. Some of the questions from learners showed their lack of understanding and the teacher was able to respond accordingly.

Figure 7.2: Teacher checking individual class exercises during a lesson in a lab.

Mr Mokone's confidence in this topic was also shown by the activities he organised for the class to tackle in groups. For instance, after having completed the topic 'particulate nature of matter' he organized a problem solving activity that seemed to tie the whole topic together and provoke some in-depth thinking. The task involved learners working on the diagram shown below:



(W1D2 Mokone, pg 4)

Learners were asked to complete the diagrams by filling in the correct change of state, and to describe the processes at AB, BC... and GH following heating a solid. The teacher said about the task, it

> …Answers, summarises everything you did from the first day of this topic to today! You must describe fully those processes (W1D2 Mokone, pg 4)

The task appeared difficult for learners, who engaged only at a superficial level, providing just the names of processes such as melting and freezing. During discussion by the whole class, the teacher probed with questions to help guide learners in linking processes at macro level with what was happening at micro level. The teacher also linked the task with activities performed in previous lessons. The excerpt below illustrates this:

T: What is happening at AB?
S: A solid is being heated…
T: AB → heating up of solid (writing on board) then BC?
S: The solid is melting
T: Do you agree with Liz?
S: YES (in chorus)
T: What happens during melting?
S: The particles move apart
T What are others saying? Thuto…
S (Thuto): responds in audibly
T: She says the vibration of particles has increased such that they move apart …as they move more the force of attraction loosen and weakens. As a result the particles move apart…Can you still remember that this (pointing) represents that this process took long. You remember when I gave you a container with ice melting and a thermometer, but the temperature was still the same? …
S: Freezing point and melting point are the same
T: We said at melting point there are still some solid…but I want you to account for this constant… (W1D2 Mokone, pg 4)

The teacher guided the discussions, focusing learners' reasons and responses. Interactions of this type formed a major part of his teaching which appeared very

learner-oriented, thought provoking and engaging. The teacher contextualized most of the concepts he introduced, using familiar examples, and analogies to help understanding. During the interview he had said: '*I used them (analogies) just to solidify my discussions' (*Mokone interview, pg 2*)*. This was typical of the teaching in all his classes.

Nature of Interactions in a Single Science Stream

Mr Mokone appeared to be disorganized at times and on these days he came across as hostile, especially when he was teaching difficult concepts. This usually happened when he was teaching his single science class and was caused by his belief that they were less focused on their studies. On one occasion his hostile attitude was triggered by learners who had failed to complete their homework. Homework was often a task which set the scene for new concepts to be taught. The teacher became very punitive when he spoke to the class:

> If you want to pass do your work all the time. Tomorrow I am giving you a brief test and should you fail, you are in trouble I will *punish* you, call your parents and report you to them… You like it or not you are going to get an 'A' star. I will make you pass… (W3D3 Mokone, pg 1)

The teacher seemed to speak like this when he was frustrated that the learners had performed very poorly in a test or assignment, or when he himself was poorly prepared for the lesson. When learners were on the wrong side, lessons would be characterised by few teaching and learning opportunities. In lessons like these, precious time was spent on non-teaching issues such the rebuking of learners. Mr Mokone believed that interventions like these would make learners change their behaviour. He said that he was fighting against two mindsets in the class, the '*I don't care mind (*and) *the lazy ones'* which he thought he could push to *'awake some of them'* (W3D5 Mokone, pg 1)

Threats like these were made in the belief that it would make learners value their educational opportunities, for instance:

> Have you ever seen what an 'I don't care' person looks like after form 5? They now start to care for something that is long gone, and they always carry this sad face. Make sure you copy all the questions, and have them all done, (W3D5 Mokone, pg 2)

Mr Mokone generally spoke in this way to the learners whom he had identified in the interview as the 'sports learners'. In some cases his harsh attitude was witnessed

during lessons where some of the learners were missing the lesson due to disciplinary actions taking place at the administration section. The conversations which took place during some lessons between Mr Mokone and the learners seemed to confirm the teacher's notion that the learners did not care much about passing.

T: By the way where are the rest? (*a number of learners were missing in class*).
S: some have been sent home…; S: suspended…
T: Why?
S: someone is bewitching us; S: For ill-treating others (W1d4 Mokone, pg 1)

The teacher thought he could force learners into passing through threats, punishment and forcing them to do assignments. A hostile attitude was also observed when to the observer, Mr Mokone appeared ill-prepared. On one such occasion the teacher started the lesson with his familiar statement:

> …we are done with rate of reactions. Now we will make a brief introduction of redox reactions…What did you find out? ...Any information you found or just from the word? (W2D3 Mokone, pg 1)

When learners failed to respond to the questions, Mr Mokone picked up a stick to punish all learners in class, saying '*you must read your books…'* (W2D3 Mokone, pg 1'. When the teacher had finished beating learners for non-participation, he changed course and started talking about performance in the previous test that '*none got 50%, actually some of you got 0%*.' (W2D3 Mokone, pg 1). Some learners jokingly said '*hit them hard*' (W2D3 Mokone, pg 1'. Learners did not seem to be bothered by the harsh words or the beating. The teacher spent some time after that telling learners what they should do if they were given tasks to work on. This appeared to be an attempt by the teacher to justify his actions in beating learners. Learners equally seemed to feel that if they had not done their work or had failed a test, the teacher was correct in punishing them.

> …next week I will give you an assignment on reaction rates, and the other week, give you a test. I said to you to work with a minimum (target) of 70%, aim for that minimum (W2d3 Mokone, pg 1)

As Mr Mokone had said in the interview, learners told him to punish them when they did not do well. However, not all learners were happy with this approach. For instance, in another single science class in which Mr Mokone had caned all learners (for failing a test), some of them questioned his right to do this, saying that the teacher

was there '*…to teach not to beat'* (W3D3 Mokone, pg *3).* One boy said that the consequence of the teacher beating learners was: *'…you are teaching them to beat (too)…'* (W3D3 Mokone, pg *3)*. This showed that not all learners agreed with this form of punishment though the teacher tried to defend himself saying,

> …your parents sent you here to learn under our care. We have to make sure that you get those passes they are expecting, (W3D3 Mokone, pg *3).*

The harsh treatment by the teacher appeared to unsettle the learners. After a class, a one learner told me that doing and not doing school work sometimes led to the same punishment. Mr Mokone's major frustrations seemed to come from his limited abilities in unpacking concepts in some topics for learners to understand. Threats and harsh words started, for example when he was teaching atomic structure and the mole concept to the form four class and redox to the form five learners. He seemed to depend on learners doing their work so that his task could be simplified.

Mr Mokone seemed to struggle with teaching the topics 'redox' and the 'mole concept'. The mole concept was one of the topics he had identified during the interview as being difficult to teach. Due to learners' difficulties in understanding the topic, he said he made the topic easier by making it more '*mathematical*' (Mokone interview, pg 1). Mr Mokone also mentioned during the interview that he found it difficult to find the right strategies for teaching some concepts. He said '*currently I am average…*' (Mokone interview, pg 1), which seemed to suggest low PCK in some topics. He said:

> Mainly (with) the mole concept is how to introduce… the approach part of it …style, how you can approach it and present it easily to learners (Mokone interview, pg 1).

Learners had been given a reading homework exercise on the mole to set the scene for Mr Mokone's teaching of the concept. He started the lesson well by probing to see how much they had gained, saying '*What information do you have about the Mole concept*?' (W2D1 Mokone, pg 1). When learners could not contribute, the teacher looked for real life examples, for instance talking about the importance of the topic in general, touching on the application of the concept in industries:

> In chemical industry, which you will be joining in 2 to 3 years, there is manufacture of chemicals, HCl, $CaCO_3$, objects are made in chemical industry

> …not just made randomly, certain things considered especially with reactions like we said there are things to consider such as rates, like say … you are employed in a company that makes a chemical to be supplied to schools in Botswana, you will have to know about rate, how long it will take to react, a day… (W2D1 Mokone, pg 1)

The teacher wanted to use the example to show that the mole is a unit for counting. However, he did not pursue the idea. When Mr Mokone realized the above example did not connect well with the idea of counting, he attempted another example:

> If in a family depending on how many you are, you have to know how much cups of 'Tastic' rice to use to cook for the family…in a chemical compound, you do the same thing, which companies do you know? KBL, ALGO etc… yes what ever company, you have to know say in producing $CaCO_3$…in any company, you have to have some knowledge of these mole concepts (W2D1 Mokone, pg 1)

It was clear that the teacher was struggling to describe the mole concept as a counting unit. Though he wanted to relate the concept of number of cups per family size, it appeared learners still did not understood what he was trying to say. After his explanations, when learners were asked, '*So now, what can you say a mole is*?' (W2D1 Mokone, pg 1), there were no response. The length of time it had taken Mr Mokone to explain, showed it was a problematic concept to put across. As he said in the interview, going for algorithmic learning makes it easier. Mr Mokone soon abandoned his attempt to explain the concept and the lesson drifted to calculations '*Mole concept deals with calculations of how much of chemicals will be used…'* (W2D1 Mokone, pg 1). There was a big jump from attempting to describe it from the observation to the micro as illustrated by the excerpt that follows:

> …a substance with a number of particles as that of ^{12}C. And carbon-12 contains 6.0×10^{23} particles called Avogadro's Constant, from the first person to discover it. Any number which contains the same number of particles as that is called a Mole. How many particles of sodium… (W2D1 Mokone, pg 2).

Before showing them how to do the calculations, Mr Mokone reviewed relative atomic mass. Reflecting on whether any learning had occurred by the end of the lesson, the teacher told me:

> I don't think they understood that much… because this was the 1st day of the new topic and this is a difficult topic (W2D1 Mokone, pg 3)

Learners appeared to cope with the calculations though transfer of knowledge appeared problematic. For instance during another subtopic, empirical formula, about

a quarter of the class failed to complete homework given. The teacher took this to mean they were not serious and beat them.

Summary of Mr Mokone's Teaching

Mr Mokone's teaching was dichotomous in that there were times when he was at his best, using various strategies to teach, involving learners and generally aiming for relational understanding while at other times his teaching was poor. It was also observed that Mr Mokone struggled to teach certain chemistry concepts, even though he obviously understood the content himself. In such situations, Mr Mokone preferred to take refuge in algorithmic approaches. Learners were given calculations to work on to complement the lack of teaching for understanding.

Mr Mokone appeared to be frustrated by the difficult topics for instance, redox, the mole concept and empirical formula. He therefore attempted to transfer the responsibility for these to the learners. Failure to do the work meant corporal punishment, which the teacher believed was an intervention to make learners to do their work, to come to the lesson prepared and make teaching easier for him. In one instance he did not teach at all, because learners had not read about redox in the text book.

Another clearly stated aim of the BGCSE curriculum was to increase the exposure learners had to hands-on activities. Due to the importance of this requirement, it will be discussed separately from the general teaching.

7.4 Hands on Activities - Practical Work

Although there are many ways of getting learners involved, laboratory activities are extremely important in this regard. The study therefore also focused on the two young teachers' teaching as it centred on practical work. Practical activities were taken to include tasks requiring physical manipulation of objects or equipment by the teachers or learners.

7.4.1 Experiments Observed at Tagala SSS

A summary of the practical activities observed during the observation period was recorded in the table 7.2 below.

Table 7.2: Experiments carried out by Tagala SSS teachers

Name	Experiment	Activities
Mr Mano (single)	[i] Reaction rates • Temperature effects	Group work: the experiment was about noting the time it takes for the Mg ribbon to disappear in HCl at various temperatures like: • Room temperature, then heating the acid to temps of 30^{o}C; 50 ^{o}C and 80 ^{o}C
	• Concentration effects	Group work: React Mg ribbon and HCl of different concentrations as follows (mass of Mg and HCl volume kept constant) • 0.5M; 1.0M; 1.5M and 2.0M
(triple)	• Surface area effects	Group work: Collection of gas liberated • Note time taken to collect 50cm^3 of gas • From Al reaction with acid • To weigh 4 pieces of Al foil and later • Use the same amount of Al powder to collect 50cm^3 of gas
	[ii] Diffusion of gases	Demonstration: Teacher demonstrating diffusion of HCl and NH_3 gases • Observe formation of ring of NH_4Cl • Discuss/link ring formation with movement of particles of two gases
Mr Mokone (Double)	Diffusion of solids in liquids	Demonstration: teacher demonstration of $KMnO_4$ crystal dissolve in water • Observe spread of colour/particles • Discuss/link spread to movement of particles of two solid particles

The table above shows that the learners at Tagala SSS did do practical work. The first practical session composed of three of the experiments. These experiments were performed in groups of about 4-5 learners. The other activity was a demonstration, performed by the teacher as learners looked on. Mr Mokone was observed carrying out a demonstration on movement of solid particles in liquids.

7.4.2 Common Features of Practical Work – Perceptions and Practice

During the interview the two teachers identified practical work as important to teaching and learning. But both were of the opinion that it was not a feasible approach to use due to lack of resources. Teachers said the bulkiness of the syllabus content also made it difficult to involve learners hands-on. The departmental setup was also cited as problematic due to lack of support or collaboration between the teachers and the laboratory assistants. Despite the hindrances the Mr Mano and Mr Mokone cited, they were observed carrying experiments with their classes.

It could be said that the two teachers blended their teaching with practical activities when they saw it fit. It is important to look at how the experiments were introduced by the teachers. Since time was mentioned as a worrying factor in carrying out

practical activities, it was surprising to find that Mr Mano was able to run a whole lesson where learners were engaged in group activities testing the effects of temperature, concentration and surface area on reaction rates. Learners had opportunities to manipulate various variables such as differing temperatures, concentrations and surface areas.

The other type of practical work was mainly dominated by the teachers as it was demonstrated with learners watching from a safe but close enough distance to see. The picture below shows Mr Mano demonstrating movement of two colourless gases from two ends of a glass tube. Formation of a solid product (white salt) was to demonstrate the rate of movement of the particles as controlled by the mass of the two gases.

Figure 7.3: Teacher demonstrating the movement of ammonia and hydrogen chloride gases to illustrate diffusion in gases

The above set-up also shows an unsafe practice by Mr Mano, as he performed the experiment in the open, instead of in a fume cupboard. The experiment involved concentrated hydrochloric acid and concentrated ammonia. The experiment worked according to plan, but gases liberated from the two containers which had briefly been left open, reacted forming a white cloud of the product ammonium chloride. This made the teacher uncomfortable, but the fumes filling the space around the teacher's demonstration table excited the learners.

The demonstration conducted by Mr Mokone was also on diffusion. He demonstrated the movement of solid particles (potassium permanganate crystals) in water. Though learners did not have to stand around the bench observing, they continued with other

related activities such as drawing the prediction of how the particles should spread shown by the colour change and intensity.

In all the experiments, the teacher raised awareness on safety issues, such as use of a laboratory coat, protective gloves when very concentrated solutions were used. Though Mr Mano took precautions such as having learners standing at a safe distance, putting on gloves and a laboratory coat, he did not perform the experiment in a fume hood, but in the open, so learners had more space to observe.

It was important to note that though these two teachers were teaching the same topic, they did not perform the same experiments with their classes. Mr Mokone did not carry out any experiments on diffusion in gases, whilst Mr Mano did not perform the experiment on movement of solids on liquids. Looking at the timing of the experiments, and also what the teachers said about practical activities seem to point to why there was a difference and even the reason for introducing the practical work in the first place.

It appeared that Mr Mokone did not want to do too many demonstrations as this would slow him down. However, when asked why he did not perform a demonstration on movement of gases he said '*because there were shortages of chemicals' (*W1D3 Mokone, pg 3*)*. Concerning improvising or using of scented substances he said, '*I thought of bringing perfume to class so I could demonstrate diffusion but I decided not to' (*W1D3 Mokone, pg 3). During the interview he said that there are things that:

> … affects you in your future planning… Like for instance you will find that … you can plan a lecturing and then special demonstration and then an exercise, but you will find that you only manage to make brief introductory lecturing, and then the lecturing takes the whole time and then what about the demonstration, (Mokone interview pg 3)

This seems to suggest that the teacher was more influenced by time factors than actual shortage of resources.

Mr Mano performed the experiment long after he had finished teaching the topic. The experiment was conducted after learners had performed badly on questions he expected them to find easy. During revision of the test he said, '*I am not impressed'*

*(*W3D3 Mokone, pg1) by the performance. This bothered the teacher even in another lesson, to say '*There is something that makes me uncomfortable, the one on rates of diffusion*' (W3D5 Mokone, pg 1). The teacher had not performed any experiment during the time he had been teaching the topic, but when learners were unable to use theory learned in class to explain what would have happened in an experiment, this prompted him to carry out this experiment (see figure 7.3). He said about the demonstration, *'…We will do that and later we can go back to what we were to do'* (W3D5 Mokone, pg 1'.

It could be said that the experiments were done to have learners ready for tests (examinations), but mainly to confirm theory. The three experiments on factors affecting rates of reaction were done after the theory, to summarize the topic. After the experiments had been done, Mr Mano said, *'…we have talked about this in class, now we have seen the practice and you can now …go'* (W1D5 Mokone, pg 3). The above statement seemed to suggest that Mr Mano had the idea that when learners had seen something with their own eyes, it would mean they would be able to pass the test, having seen something to him was a confirmation that learners now knew it.

7.5 Summary of Findings about the Teachers and their Teaching at Tagala SSS

A summary of the teachers' perception of the curriculum changes and what teaching and learning meant to them is given in table below:

Table 7.3: Tagala SSS teachers' perception about curriculum changes

Perception	**Content changes**	**Assessment changes**	**Teaching and learning changes**	**Readiness to implement changes**
Mr Mano	- New topics /concepts added -some topics removed	- Grading system changed - Change made BGCSE simpler - Easy to pass	- Learner-centred - Learner-centred experimentation - Group-work	- Ready: no problem implementing any curriculum demands
Mr Mokone	- New topics /concepts added - Topics removed - Application of science	- Number of examination papers introduced	Learner-centred approaches - Activity based - Experimentation - Practical work - Group-work - Chalk-talk still dominate	- Not ready, too many demands - Struggling with teaching methods: esp. balancing instructional demands and time

The table above shows what teachers at Tagala SSS perceived to be the most obvious changes of the curriculum. The changes related to content of the syllabus content, changes related to the assessment and teaching procedures.

Though Mr Mano and Mr Mokone were not employed yet at the initiation of the curriculum, they made reflections based on their secondary schooling days. Their reflections showed that they were aware of several changes that had occurred since. Changes according to them were major as it had involved new instructional demands and some removal of concepts teachers thought should still be in the curriculum. According to them, the chemistry section had agreed to continue to teach some topics which they felt were important but were no longer in the syllabus. This seemed to show that they placed great value on content mastery. Despite that the extra topics elongated the syllabus, they still continued to teach non-syllabus topics. Assessment according to the two teachers had made less impact in teaching methodologies though the examinations had continued to determine the scope of what to teach. Mr Mano viewed the present BGCSE examinations to have been made easier for learners to pass due to contextualisation of questions with familiar backgrounds. This was in contrast to examinations formerly set in the UK.

Mr Mano and Mr Mokone were of the opinion that teaching and learning approaches have significantly changed as the philosophy now follows learner-based approaches. Though the teachers thought they had been well grounded in their teacher preparation, they admitted that they were certain areas where they struggle to prepare lessons well for students to learn better. Mr Mokone said he would rate himself average due to lack of experience in handling and unpacking certain chemistry topics. He went on to say he thought that other teachers in the department had not embraced the BGCSE methodology as their routine practice does not show in practice.

Mr Mano and Mr Mokone's practice is summed in the table 7.6 below.

Teachers and their Practice

Table 7.4 below gives a summary of what was actually seen to be happening in the chemistry classrooms at Tagala SSS. Indicators of practice included teachers' approaches and how teaching was accompanied by learners' involvement, contextualising concepts and practical work. The summary also includes the teachers' competences in teaching and treatment of learners in chemistry classrooms.

Table 7.4: Tagala SSS teachers' teaching practice

	Practice	Mr Mano	Mr Mokone
1	Contextualisation and application	Contextualisation was minimal lacking use of: analogies; application of science; nature of science	Highly contextualised lessons: Analogies; real life examples and use of stories
2	Teaching approach	- Teacher-talk: with some degree of interaction - Learner-centeredness - Group-work - Whole-class discussions - Regular homework	- Teacher-talk: highly interactive - Learner-centred - Prior knowledge search - Group-work - Whole-class discussions and regular homework
3	Classroom practical work/demonstrations	***Practical work:*** with all streams - Demonstrations (interactive) - Group experiments (interactive)	- Demonstrations (interactive)
4	Treatment of Streams	Same treatment: experiments to all learners - Nature of talks/discussion different - Viewed triple science as more curious and willing to learn	Treatment different e.g. nature of talk, - Exposure to more engaging activities - More corporal punishment administered to single science learners - Viewed triple science as more curious and willing to learn
5	Learner Involvement and participation	- Discussions and argumentations opportunities created during teaching and experiments - Participation in experiments - Homework- problem solving tasks - Limited quality of discussions due to low order questions asked : filling gaps - Teacher less critical and engaging during Teacher-learner debates: no follow up questions	- Discussions and argumentations during teaching - Participation in discussions- along stream line - Quality of discussions due to high order questions asked - Teacher follow up learner responses with more critical and engaging questions during teacher-learner debates - Homework: problem solving tasks
5	PCK (Level of preparations)	- Weak PCK in some topics - Sloppy teaching some topics (single/double streams) - Weak preparations in abstract/difficult topics - Weak representations used when teaching abstract/ difficult topics	
6	Teaching for examinations	Seemed the main aim	

The table shows the types of practices observed from Mr Mano and Mr Mokone's classrooms. Mr Mano and Mr Mokone mostly attempted to help learners learn with understanding using a variety of approaches including contextualised illustrations and analogies but to different degrees. Mr Mano minimally contextualised content during his teaching. Teaching difficult or more abstract topics seemed to lead to un-preparedness and poor teaching. Mr Mokone usually used well thought out questions and invited talks from learners. He gave assignments regularly in the form of problem solving tasks. Mr Mokone also gave reading assignments to prepare for next topics to be introduced. He was generally dependent on prior knowledge learners brought to the class.

The two teachers organized some practical work for their classes, but they all appeared too cautious about time, like they mentioned during the interviews. Time consciousness led them to generally limit more hands-on activities. When they did organise practical work, it was them who carried out the demonstrations with students

observing. Learners were engaged in the discussions to sum up experiments. Chasing time also led to teachers bringing in only a limited number of activities to demonstrate.

7.6 Discussions of Findings for Tagala SSS

Following the scrutinising of Mr Mano and Mr Mokone, it is now important to determine their operational levels and eventually identifying the ZFI for Tagala SSS. Each teacher's indicators of operation on classroom interactions, practical work and contextualization were summarised based on their classroom activities (table 7.5).

The Practice

Like in the previous chapter, the indicators of what the teachers were doing in their classrooms have been grouped under classroom interactions (CI), practical work (PW) and contextualization. A summary is tabulated below.

Table 7.5: The Operational Indicators of Tagala SSS teachers

Name	Classroom Interactions	Practical Work	Contextualisation
Mr Mano	Signs of poor preparation Long notes provided Homework given regularly Monthly tests given (to all learners) Interactive lecturing/discussions Minds-on activities and Learners engagement: - Class discussions - Practical work - Demonstrations - Meaningful and deep engaging questions & problem solving tasks	Practical work and demonstrations during lessons: both streams Many engaging questions during discussions: of low order Qualitative & quantitative aspects	Minimal application of science; Linkage to real life (to illustrate concepts) during teaching Problem solving exercises/tasks linked to application of science
Mr Mokone		Practical work or demonstrations during lessons - all streams Highly engaging discussions reviewing practical- work and demonstrations	Teacher use examples and application from everyday life and story telling Problem solving exercises/tasks linked to application of science

From the practice indicators it was possible to predict the levels of operation by matching them with Rogan and Grayson's guidelines. The procedure described in chapter 6, detailing how to obtain levels for individual teachers and later the average for the school was followed. Table 7.6 below shows the transformed indicators into operational levels for Mr Mano and Mr Mokone in the three dimensions.

Levels of Operation

Table 7.6: The levels of operation of teachers at Tagala SSS

Teacher	Operation Level		
	CI	PW	Contextualisation
Mr Mano	2	2.5	2
Mr Mokone	2.5	2.5	2.5
Average (Whole school)	**2.5**	**2.5**	**2.5**

To make the results above more useful, the information above was converted into a bar-graph to help visualize the ZFI for the school.

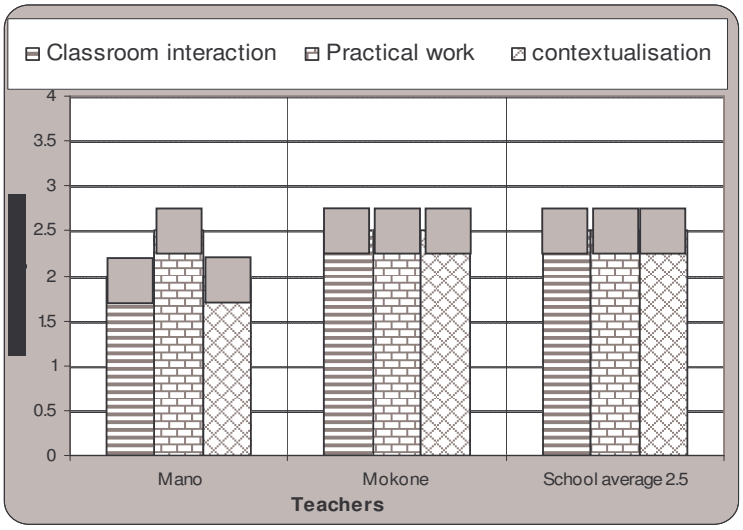


Figure 7.4: Tagala SSS' levels of operation

Figure 7.4 shows the level of operation of the teachers, as well as their ZFI. Mr Mano and Mr Mokone appear to operate at about the same level in all three dimensions though not necessarily doing the same things. Mr Mokone had an upper hand in all three dimensions as he was more versatile in his teaching.

Mr Mano's practices could be said to have been satisfactory in some areas. For instance, taking classroom activities as an example, he attempted to engage learners in classroom discourse but only raised low order question. Learners generally responded in chorus. His lessons were also dominated by the lack of use of contextualised representations, where Mr Mokone did well. The teacher seemed to have more strength in practical work as the way he designed the experiments appeared to encourage learners to discover information on their own. Though learners were provided with instructions in some cases, it was only done when there was lack of progress. Though Mr Mano appeared to do well in the experiments, he needed to improve the communication component of the practical work. For example, the low order questions which appeared to encourage rote learning and lack of contextualisation of concepts.

Mr Mokone appeared confident in some topics where his strategies appeared sharp and directed for relational learning. Discussions appeared intended to help learners learn better as questions where often contextualised and followed up with more probing. On other occasions the teacher gave homework exercises to boost learners' prior knowledge related to the new topics to be introduced. Limitations in other topics due to poor strategies on how to teach the concepts (SMK) seemed to weaken his teaching options. Though he was not observed giving many experiments except for a single demonstration on diffusion, he said he favoured demonstrations because of the perceived urgency to complete the syllabus.

The experiment performed by Mr Mano on rates of reactions, and the effect of weight on diffusion rates were not performed by Mr Mokone. Instead he only demonstrated potassium permanganate crystals in water. It was not clear whether it was a question of time alone or the teacher lacked confidence to run more demanding setups in a session like his colleague. He also avoided demonstrating the diffusion of gases showing that the teachers did not necessarily share information and experimental setups in the department. The highlight of his experiments was the quality of discussion that went on with the demonstration. He asked many thought provoking questions, and followed up students responses with further probing questions which encouraged in-depth thinking. He could have easily been operating at level 2.5, mainly due to the quality of communication that was there. But looking at the other components of practical work, procedural purposes was not part of the experiment observed as learners were not involved in hands-on.

DISCUSSING TAGALA SSS OPERATIONAL LEVELS

The teachers' operational indicators had been described as dominated by excellent teaching in the initial class observations. But the two teachers appeared frustrated on the later weeks of the research study, giving less engagement tasks, rebuking and beating students more. Mr Mokone was very particular about homework as he used the tasks to introduce his teaching. For instance, he would pick a question from previous assignment to help introduce the lesson. He also used reading tasks to boost learners' prior knowledge for a new topic to be started. He appeared to be dependent on learners having some background knowledge on new concepts to be taught. Failure to do homework triggered frustrations by the teacher as learners' lack of knowledge

appeared to limit his ability to teach. He appeared well resourced in terms of using analogies and contextualising concepts when teaching. Mr Mano appeared not to value application of science as he rarely used analogies or linked science with real life examples.

There were therefore signs of BGCSE implementation though not so well developed. Transmission views were still common, for instance the teachers still preferred to give learners long and detailed notes. Single period lessons (40 minutes) were mainly reserved specifically for writing notes with no challenging activities on the day. Lack of PCK in difficult topics seemed to constrain the teachers in some of the more abstract concepts like 'redox', mole and the atomic structure as teachers appeared to struggle to find suitable approaches to introduce and develop lessons.

The teachers also favoured practical work as they thought it was one of the recommended instructional strategies. Their method involved engaging learners in hands-on activities as well as in minds-on discussion sessions. Teachers were limited though in the types and quality of discussion that went on. As inexperienced teachers, it was found that their PCK in most topics was limited. They both struggled in some topics to make concepts understandable to learners. Such limitation often led to frustrations, resulting in teachers blaming and punishing learners when the learning was not as desired. Learners were viewed as the root cause of the problems as they were thought to be lazy and not taking school work seriously. Mr Mano was limited in many areas such as the quality of questions asked, representational examples to aid learning such as use of analogies and real life examples. Mr Mokone appeared better in this regard, though he appeared badly affected when learners appeared to lack the necessary background.

The above seemed to suggest that most of the interventions needed in this school are to be directed at supporting and helping raise the quality of teaching. Other issues include raising awareness to areas of time and syllabus management which might help such as:

- Importance of adhering to the syllabus
- Better utilisation of afternoon and evening study times, due to boarding facilities

- Handling of abstract (problematic) topics and improving: contextualisation, learner participation and minds-on and hands-on activities

Chapter Conclusion

In Tagala, the teachers' approaches seemed to be governed by two factors which were: the stream being taught and the difficulty of the topics to be taught.

Mr Mano and Mr Mokone were both inexperienced chemistry teachers. Nevertheless, on the first days of observations the teachers appeared very enthusiastic and well organised in their teaching. They made their lessons very lively as they incorporated learner-oriented interactions. They also incorporated practical work into their teaching, though not regularly. They seemed keen to engage learners in discussions during lessons. The main differences was that Mr Mano generally asked low order questions which invited chorus responses such as fill-up gaps he created as he spoke. Mr Mokone usually prepared well thought of questions, context-based and used a lot of analogies to enhance understanding. These appeared to be the case when the teachers were comfortable with the topics.

On the other hand, their inexperience showed as they seemed to struggle with later topics covering 'empirical formula', 'redox', 'the atomic structure' and 'the mole concepts'. Lack of smooth flowing lessons led to teacher frustrations. Frustration resulted in teachers threatening learners with punishment, more work, and tests to check their understanding and preparedness. Learners were often punished and warned that failure to pass or to do some work would invite further punishment as they were believed to not take their school work seriously. This appeared to shift responsibility and accountability from the teachers to the learners.

Mr Mano though slightly more experienced, also faced difficulty teaching certain topics. Low order questions failed to reveal students' learning difficulties. The learning problems were only revealed following tests in which majority of learners performed poorly. According to him the intervention needed was punishment as learners were not devoting more time to school work. This was a surprising judgment because it was a triple science class where learners appeared to take their work very seriously during lessons and participated as required by the teacher in class.

CHAPTER 8 MARU SSS

Introduction

Once again this chapter will start by outlining teachers' perceptions about the nature of curriculum change and demands of the curriculum, information which was obtained mainly through interviews. Thereafter the general classroom activities of each of the three teachers will be described. Because of the emphasis of the new curriculum on practical work, this will be discussed separately from the normal teaching. Finally the chapter will summarise what the status of Maru SSS was in terms of Rogan and Grayson's (2003) theory of curriculum implementation and endeavour to ascertain what the ZFI for Maru SSS was at the time of the study.

The teachers involved in the study were Mr Mpho, Mr Bose and Mr Sunny will be described.

8.1 Teachers' Profile

The information concerning the classes observed is summarised in table 8.1 below.

Table 8.1: A summary of chemistry teachers' pedagogical profiles

	Maru SSS		
Pedagogical approaches	Bose	Mpho	Sunny
Lecture method	2 (T/S)	7 (T/D)	6 (D/S)
Whole class discussion	3 (T/S)	4 (T)	3 (D/S)
Group discussion	5 (T/S)	1 (T)	-
Experimentation (teacher demo)	2 (T/S)	2 (T)	-
Experimentation (Learner)	2 (T/S)	2 (T)	-
Learner Presentations	-	-	-

The information concerning the teachers from table 8.1 will be repeated below for convenience. The table 8.1 showed that the three chemistry teachers investigated were generally experienced according to the definition of experience in this study, with chemistry teaching experience spanning from two to six years. All the teachers held at least a bachelor's degree in chemistry in addition to a teaching qualification. Mr Mpho had comparable teaching experience to Mr Bose, but had taught chemistry longer at senior secondary level. He also had been employed at this school longer. His head of department described him as the backbone of the chemistry section. Excellent chemistry results were credited mainly to his contributions. Mr Mpho attributed his

maturity in the job to the fact that when he joined the school he had taught with many older and more experienced expatriate teachers in the department who encouraged working as a community. Mr Sunny was in his second year of teaching senior secondary chemistry, having spent his first two years in the profession teaching integrated science at junior secondary level. As a relatively new chemistry teacher, he had been allocated the combined (double and single) science classes only. The three teachers' perception of curriculum changes will now be explored further.

8.2 Teachers' Perceptions about the Curriculum Change

Analysis of interviews showing how the teachers viewed curriculum change and implementation demands of the new curriculum have been grouped into three main ideas, encompassing changes related to syllabus content, changes in terms of assessment and changes in terms of teaching and learning styles.

8.2.1 Curriculum Changes in Terms of the Syllabus

Because the three teachers were relatively young, the new curriculum had been introduced during the time when they had been in pre-service training. This meant that they were unsure of exactly what had been changed although during their training they realised that a number of things had been done differently in the past. Mr Bose was not sure if there was any difference in syllabus content. Mr Mpho seemed to have more awareness of the type of content changes made. He talked about changes having been made in terms of introducing as well as removing certain learning objectives (topics) in various streams. For instance, he cited the introduction of a new topic 'Chemistry in the Environment'. Though he saw the importance of the topic in terms of bringing relevance and context, he did not attach much worth to it as he believed students already had enough knowledge about the topic from junior secondary level.

Having taught all the science streams for some time had also made Mr Mpho realise that '*confusion' (*Mpho interview, pg 1) had been created by the new syllabus. He talked of the confusion created by curriculum developers in attempting to shuffle certain objectives between streams. Removal of topics at times led to elimination of essential concepts needed as preliminary knowledge for other topics. Shuffling had in some

instances led to over-extending the single science stream which was supposed to be exposed to less demanding chemistry concepts. Mr Mpho gave an example:

> … the one on metals, where we are doing the action of heat on the carbonates, nitrates. Then the double science (students) are only doing nitrates and carbonates, but the single sciences they go… up to hydroxides, even the oxides you see. And those objectives are there in the triple science (Mpho interview, pg 1).

Mr Sunny was also able to reflect on the developments brought by the implementation of the BGCSE curriculum. He considered the quality of the syllabus to have gone down. For example, he pointed out that certain topics had been removed whilst some were no longer taught as

> …deep as it used to be… like we used to learn radioactive materials and now it is limited to the introductory part only … (Sunny interview, pg 1)

The teacher did not link the removal of a concept or topic to its relevance, except that it reduced the science quality by reducing the quantity of material learners should be exposed to. Mr Sunny seemed a firm believer in exposing learners to scientific theories and facts.

8.2.2 Curriculum Changes in Terms of Assessment

Mr Bose viewed some of the changes in terms of assessment procedures introduced. This mainly involved the question format which now provided clues to assist the learner in answering questions. He thought this change had been driven by the desire to place knowledge into familiar contexts to enhance learners' understanding of what exactly was being asked. Examiners do not '*write the questions the way they were written before'* (Bose interview, pg 3*)* instead they

> …try to assist the students on how to answer the questions by putting some windows there, then the students will read the window then after reading the window… then the students will know how to answer those questions, (Bose interview, pg 3)

Mr Mpho concurred that contextualising teaching and assessment had improved the examinations. For instance, he talked about examination questions as more readable and understandable by learners as the questions are set locally. This had made the questions relevant as they were based on contexts students were familiar with. He did not however, think that introducing the new curriculum and assessment approaches

had led to quality changes in actual teaching '*as things have remained the same'* (Mpho interview, pg 5) .

Mr Sunny had a much more superficial view, seeing changes in terms of the number of papers offered in final examinations. In the BGCSE system there were more papers written than had happened in the past. He did not think there was much difference in assessment procedures.

8.2.3 Curriculum Changes in Terms of Practice

Mr Bose recognised that the new curriculum encouraged learner-centred approaches to learning. He interpreted learner-centred teaching as giving students information and objectives to direct them in independent work, which could take place in groups or individually. This realisation had made him value activity-based learning because when learners '*discover on their own…they do not forget easily, (*Bose interview, pg 2). He claimed that this realisation had also helped him during lesson preparation to have

> …a constant and continuous thinking about learner-centred teaching such as learner-centred engagement all the time… (Bose interview, pg 2)

Mr Bose also viewed learner-centred teaching as involving practical or experimentation work, where

> …you let them observe …do not give them too much leading information, but at the end they have to be given the chance to discuss their observations… (Bose interview, pg 2)

Despite Mr Bose's recognition that the new curriculum encourages learner-centred approaches to learning, he felt that implementation of these approaches was still lagging behind. Teachers found it difficult to transform some of the curriculum themes into teachable approaches. For instance, he felt

> …some topics do not allow experimentation… and some topics or concepts demand that teachers give students information (Bose interview, pg 1)

According to him, giving too much information or not carrying out experiments was discouraged by the new curriculum policy.

Mr Mpho, like Mr Bose felt that most of the major changes concerning teaching and learning were only at policy level, but had not yet come down to practice. For instance

> … If you go around and observe lessons, you will realise that in most cases teachers use teacher-centred methods. They don't usually use these student-centred methods… because they believe by this teacher-centred method it will give them an opportunity… what we are looking at here in most cases, is people want to complete the syllabus in a given period. So people are running after time… it's one or two where you find that or in some instances where we give students practice (Mpho interview, pg 8)

Mr Mpho thought there was a general resistance to follow, explore and implement the hands and minds-on activities of the new curriculum as teachers generally relied on their tried and tested approaches. For instance, he said '*…every teacher believes his or her own method is the best…' (*Mpho interview, pg 8). Though he thought teachers had the necessary knowledge about various teaching methods, his most favoured learner-oriented method was giving students class exercises or grouping students.

> You find that in most cases they usually use students in groups…they teach them in a form of groups …even though they are not usually putting… all of them in practice (Mpho interview, pg 8).

Placing learners in groups whilst not engaging them in any meaningful group activity seemed to indicate that the teacher had difficulties in shaping appropriate pedagogy. It would appear that teachers do not acknowledge their limitations, or problems in interpreting pedagogical terminologies.

Mr Sunny was aware that there were increased demands to move away from the teacher-dominated approaches.

> They are saying for the sciences, we should actually not be sort of lecturing and doing the experiments, we should give students more exposure to doing the experiments themselves… (Sunny interview, pg 1)

Regarding learner-centred learning the teacher believed the chemistry section at Maru SSS had made significant strides in trying to introduce the purported teaching modes. '*I think generally here [chemistry], we try by all means, even the single science …'* (Sunny interview pg 1*).* But he viewed learner-directed approaches as involving mainly experimentation during teaching. In the event that individual practicals were impossible, students should be given a *"…demonstration for each content that need*

*maybe some kind of experiment' (*Sunny interview, pg 1). How Mr Sunny interpreted the meaning of activity-based learning seems to have narrowed the scope of opportunities the teacher could have used in exposing his learners in other forms of mind-and hands-on activities. Group-work was viewed as a substitute for not being able to give individualised practical work.

> Most times we use group-work in chemistry, because they are many (students) in class… we have problems with materials… they work in groups because there is a shortage of materials here, (Sunny interview, pg 2)

This shows that teachers had problems with interpretation of pedagogical terms like activity-based learning or learner-directed methods. These were translated by Mr Sunny to mean experimentation while other stimulating and engaging approaches such as discussion in group-work were not considered relevant. This is not surprising, looking at his general reliance on notes which he handed out. These notes had been prepared for the department and because he had had no input into them, this seemed to limit the quality of his lesson preparation. Preparation for Mr Sunny meant just looking at the learning objectives to be covered. Talking about the quality and effort he gave to preparing for a lesson he said,

> I think it depends on the level of preparation, I would say…sometimes I feel like this other topic I think I can just look at the objectives that I have to cover and I actually need, actually need to refer to my notes as I teach (Sunny interview, pg 7)

The data above shows that the narrow definition of activity-based learning constrains teachers. If they cannot apply experimentation, they feel they have failed in this regard. Involving learners in debate or seeking prior knowledge from learners is also perceived as unachievable. Expecting students to come up with their own information is viewed as unproductive and so the teacher cannot allow this. This is what '*pulls*' (Bose interview, pg 2) them to the old system of teacher-dominated lesson, which Mr Bose thought was still favoured.

8.3 Implementation of the New Curriculum in Chemistry Classrooms

The second part of this chapter aims to investigate opportunities learners got to learn chemistry and doing chemistry hands-on in Maru SSS. Data for this part mainly came from lesson observations. It was important to find classroom features to complement

findings from the interviews. One of the aims of introducing the new curriculum had been to improve learning through learners' involvement in their own learning. Thus the section describes how teachers were able to vary their styles of teaching, taking the requirements of the new curriculum into account.

The teaching approaches followed by Mr Bose, Mr Mpho and Mr Sunny and the frequency of use were summarised in table 8.1. In short, Mr Mpho and Mr Bose closely resembled each other in varying teaching approaches, engaging learners in hands-on and minds-on activities and contextualising concepts. Mr Sunny appeared to struggle to incorporate these into his lessons. Table 8.1 helps to portray the instructional skills the teachers adopted in order to address issues of the BGCSE chemistry curriculum. Hence this section attempts to:

- Find evidence that the chemistry teachers were doing what the BGCSE curriculum intended them to do, in other words how teachers were implementing the BGCSE curriculum in their classrooms.
- Discuss teacher-students interaction in classrooms

8.3.1 Lessons Given by Mr Bose

During the interview, Mr Bose revealed that in his view the chalk-and-talk method was still the norm in teaching chemistry in Maru SSS but observations during the research period did not show this method dominating his classes. Mr Bose's favoured teaching methods were whole class discussion and group work activities. He also carried out some experiments to complement his teaching in each topic he covered.

Nature of Interaction in a Triple Science Class

What was particularly interesting was his use of whole class discussion and group work activities in analysing text-based activities. Group members solved word problems involving calculations, taken from past tests or practical examinations. An example of the type of questions show that learners were required to

> …find the mass of silver chloride formed from precipitating 0.1 mol of a chloride and silver ions… (W2D1 Bose, pg 1)

Another question required them to describe how they would purify impure copper. The teacher told them about the clues attached to the question,

> I left a big space, I was communicating, to say make the diagram, you need to be clever, so that by the time you make wrong explanation because of your English, 75% of the question is already done… (W2D1 Bose, pg 1)

The tasks caused a lot of constructive as well as non-constructive talk between students as they tried to arrive at a symbolic representation of the problem e.g. the balanced equation to show the reaction in the formation of silver chloride salt. For instance the group I was observing was arguing. The group secretary had written:

*Ag + Cl →AgCl (*W2D1 Bose, pg 1*)*

One boy said the '*chlorine (*referring to chloride*) is a diatomic molecule (Cl_2) and so cannot be written as one' (*W2D1 Bose, pg 1*).* A girl in the group thought this would be wrong since that was not chlorine but a chloride (Cl^-, though not properly written), however, she could not support her view. This meant the rest of the group concluded that she was wrong, ending up with a wrong equation with a chlorine atom in the equation. There was not much progress in this group until there was feedback from another group on the board.

Another interesting observation was that, though the teacher was not observed performing any practical problem-solving (open-ended investigation), he did give mental puzzles in the form of questions. This required pupils to solve imaginative, challenging problems based on information given. For example incomplete practical results were given to learners who were required to use, select and consider the given data to trace the unknown reactants or ions.

Table 8.2 below shows a problem solving task showing '*the test a student did on a substance R, and the conclusions made from the observations…* W2D4 Bose, pg 1'. Not all the information was provided. The provided information was that, the '*learner was given a sample R, dissolved in water before dividing the sample into three portions labelled 1, 2 and 3.'* Conclusions were recorded that '*R is not a compound of a transition metal,* W2D4 Bose, pg 1 '.

Table 8.2: A drill mental puzzle, (W2D4 Bose, pg 2)

Test	Observations	Conclusions
R was dissolved in water, and the substance divided into 3 portions 1, 2, 3…	**?**	R is not a compound of a transition metal…
Given To the first part, aqueous NaOH was added till a change was seen. Once she saw the change, she added excess NaOH to that…	***Given*** i White ppt <s formed- said to be unnecessary for conclusions> ii the white ppt dissolves giving a colourless solution	**? to predict conclusions** *R contains zinc ions or aluminium ions [what is it that was* observed here…]
?To provide the test to perform On the second part, aqueous. ammonia is added until a change was seen.	**? to predict observations** *White ppt* *White ppt dissolves forming a colourless solution*	**Given** The presence of Zn ions is confirmed
?	**?**	R contains SO_4^{2-} ions

Based on the information given, students were to fill in the blanks as an experimenter would have done. Various contributions were made by learners and later discussed by the whole class such as:

> It forms a white precipitate…; forms a white compound; it dissolved and formed a colourless solution…; it dissolved and it gave a colourless compound…; the compound was colourless… (W2D4 Bose, pg 1)

The first prediction was cancelled right away as it was said by others the information given says it dissolved, many others were dismissed as not correct as they are not conclusive…e.g.

> T: …you dissolve something in water it forms a solution and not a compound… a colourless solution tells us it is not a transition element… (W2D4 Bose, pg 1)

Following the correct recording of the observations, the teacher gave further information about the treatment of the other portion of the sample, for instance with the first portion of the solution, students are told that

(i) The learner added aqueous NaOH till the change was seen

(ii) When the change was seen, she added excess NaOH to that

Students were allowed to use support materials such as handouts, notebooks and textbooks in filling in the missing information.

Nature of Interactions in a Single Science Class

Not all Mr Bose's classroom activities mentally challenged learners. The nature of interaction seemed to depend on the stream he was teaching. For instance, when

learners discussed experimental results from a previous practical involving preparation of copper sulphate crystals the teacher probed mainly for recall of procedures involved in preparing the salts (see excerpt below). Mr Bose did not probe for deeper learning as he had done in the triple science class. Learners participated, and appeared lively, responded well giving brief responses. The lack of cognitively demanding responses from students seems to be associated with the fact that they were single science students. Mr Bose did not expect them to articulate much. Hence, he did not attempt to find out from students what the reasons were for their answers. The passage below shows the answers coming from learners as they responded to the teachers' questions concerning steps involved in preparing copper sulphate crystals from copper carbonate and an acid such as…

S: the copper carbonate ***dissolves*** in the acid,
S: the liquid turned blue
…
S: I think it was to fasten the ***reaction*** of copper II sulphate
T: The copper II sulphate was not there yet… Why…?
S: To help ***dissolve*** the copper carbonate
T: What was the indication that we now had to end the reaction…?
S: When carbonate was no longer ***dissolving***…
…
T: We warmed the solution in an evaporation dish and later placed it in a Petri dish and place it in a cooler place… and the water evaporated… (the teacher was holding a Petri-dish with blue crystals, there are about 10 to 15 of them on the side tables).
T: Why do we heat at first?
S: To evaporate some of the ***water molecules***
T: What can you say about the concentration of the solution remaining in the dish… you heat some ***water particles*** evaporate.
S: Becomes more concentrated… (W2D3 Bose, pg 1)

It was clear from these tasks that Mr Bose valued giving practical work to all his classes, even the single science stream. It was during the discussion of results that the teacher seemed to give less thought to what the students had said in the single science stream than in the triple science class. This is shown where the teacher allowed the casual use of words '*dissolving*' and '*reaction*' without any comment, although according to the students, the two seemed to mean the same thing. Mr Bose accepted responses without scrutinising the meaning students had, being mainly interested in asking leading questions. The teacher also casually switched between macro and micro representations as shown above by the statements '*To evaporate some of the water molecules'* and '*…you heat, some water particles evaporate'* (W2D3 Bose, pg 1). The

teacher appeared to be happy with having learners perform an experiment, and have them recite the procedures they had followed without much deeper thinking.

Generally responses coming from the single science class were very brief (as shown in the excerpts above). Superficial discussion seemed to lead to lack of understanding. For instance, during post-test discussions, students were seen struggling with procedures similar to those they had followed in practical work. Many questions based on practical work were problematic, for example learners could not recognise that dissolving HCl gas in water produced an acid. This lack of transfer of knowledge suggests that during discussion of practical results, the lower order questions asked by the Mr Bose in class were not very helpful.

Students also faced difficulties in applying knowledge of concepts previously learnt at form-four level, for instance deriving formulae of compounds. This seems to suggest that the knowledge base from lower classes was not retained to now assist in learning new concepts.

Summary of Mr Bose's Teaching

There appeared to be some consistency in the way Mr Bose handled the two classes (triple and single). He seemed to give learners equal chance to participate during lessons. He used interactive approaches like practical work, whole class discussions, and even small group discussions. He gave students opportunities to participate in class, responded to their questions, and solved problem tasks in groups before giving feedback to the class.

The major differences in his teaching of the two streams seemed to come from the depth of engagement when the two sets of classes were involved. The tasks given to the triple science class seemed to demand more thoughtful actions no matter which tasks they engaged in. High order thinking however seemed to be absent from the single science classes, largely due to the fact that the teacher did not direct discussion or ask enough thought provoking questions.

For instance, the kind of problem solving practised in the triple science class was to allow them to cope in the practical examination. In the practical examination, learners

were usually given an unknown substance, which could be a mixture of two salts. The learners' task would be to perform several tests, to identify the ions and eventually the composition of the unknown. This meant that learners needed to be thinking critically about what lay behind what they were doing, rather than simply filling in gaps. Knowing that they would have to perform similar tasks in the examination meant that students were particularly motivated to engage with the task. Hence the teacher gave the students enough time to engage in groups and discuss after which, during whole class reporting, more probing by the teacher ensured that learners got these tasks right.

The single science students were given less demanding tasks in order to be able to respond to low order questions. Even the low order questions appeared to trouble most learners. During tests reviews, the teacher always gave a great deal of assistance as learners generally struggled to make a link between the questions asked in the test and the concepts learned in class.

8.3.2 Classes Given by Mr Mpho

During the interview Mr Mpho told me that teachers in Maru senior secondary school generally did not use activity-based methods. He said,

> …You will realise that in most cases teachers use teacher-centred methods… they don't usually use these student-centred… (Mpho interview, pg 8)

He was of the opinion that handing out written classroom exercises which the teacher would then mark, were common. This was seen as a way of engaging learners without slowing down the teacher's pace too much. As one of the most experienced teachers in the department, he was regarded as the most exemplary teacher by the head of science department. This made it interesting to find out what he was doing in his classes.

As before, a teacher-centred delivery style will be called the "lecture-method" even though it might involve some audience participation. Mr Mpho thus used the "lecture method" more when teaching his form four double science class than when he taught the form five triple science classes. His lecture method in all classes was complemented by engaging learners with questions, with learners working on class

exercises and by giving homework. He would move around the class checking and marking the work. His was not a true lecture, because his classes were very interactive, especially obvious with his form four class where learners were allowed to participate. Brief notes in point form were given during the course of teaching. This approach seemed consistent with what he said during the interview about teachers '*…running after time…*' saying '*…it's (rare)… where we give students practice* (Mpho interview, pg 8).

Nature of Interactions in a Double Science Class

His teaching approaches in the form four double science class were informed mainly by the feedback from homework. He wanted to help those students who he said '*…from the given assignment …appeared lost' (*W1D2 Mpho, pg 1). When he taught atomic structure, it became clear that a number of students were still facing difficulties deriving electronic configurations, and drawing atomic structures. To try and resolve the learners' difficulties, he came up with many more examples, at the board to boost understanding. His teaching was dominated by the use of Socratic whole-class discussion where he would be working at examples on the board with the help of students, probing learners with questions as he worked on.

Mr Mpho was in many instances able to spot learner confusion. In one case it had to do with writing equations for half reactions to show loss or gain of electrons to give an ion. Students were familiar with the format of half equation shown below, which depicts a loss of electron (because of minus) from sodium atom resulting to a sodium ion:

$$Na - e^- \longrightarrow Na^+$$

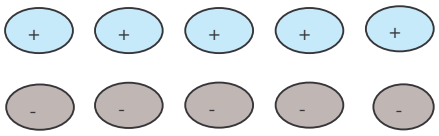
Changing the format to adding an electron instead of subtracting caused difficulties in understanding for learners. For instance, when he asked the students that '*…If I … have the electron on the other side is it wrong or correct? (W2D4* Mpho, pg 3). Responses showed students had difficulties conceptualising the link (below).

(W2D4 Mpho pg 3)

The arrangement with the electron on the right appeared unfamiliar, and they all responded *'Wrong'*. The teacher then followed up to try and clarify the problem by applying an already familiar mathematical expression saying,

> T: *Let me ask, if we have*
> X - a = b *and*
> X = b + a.
> T: *Is it the same or a different equation*?
> S: *same (*Some students were not sure of the link).
> T: X = b + a: *are the same, so meaning even the above is the same… I wanted to see whether you can make connections* … (W2D4 Mpho, pg 3)

As the learners found some ideas hard to grasp, the teacher also used a lot of analogies in explaining the concepts like isotopes and of charge balancing. When he realised that learners had difficulties understanding the concepts, he used equal number of female and male students to illustrate how it works in keeping the atom neutral. He also used the same approach to demonstrate how a loss of electron causes an imbalance of charges, by sending one of the boys to sit down. He said this demonstrated a loss of electron.



Girls (protons)

Boys
(electrons)

(W2D3 Mpho, pg 4)

The same approach of using students was used to demonstrate the two isotopes of chlorine (37 and 35), which were said to occur in a ratio of 1:4. The teacher used one boy and three girls to illustrate how for every 4 atoms, one was chlorine Cl-37 while the rest were Cl-35. Students initially seemed to struggle to apply the mathematical concept of ratios to the calculation of relative atomic masses. Use of the analogy seemed to clear up the misunderstanding, though it was not clear if they were able to transfer the knowledge to calculations of percentage composition for isotopes. The analogy above did not appear good and very helpful. It appeared to bring superficial knowledge as there was no evidence that students could perform calculations of percentages on their own.

Mr Mpho liked the use of analogies, application of science and telling stories which he hoped would get ideas across. For example, he linked carbon isotopes, '*especially C-14 to carbon dating*' (W1D3 Mpho pg 2) and how the age of El Negro was determined. He told the story of how French scientists had robbed El Negro's body from grave the day after his death in around 1830 in Botswana. The body was mummified and taken to Spain for public display in a museum. Bringing back his remains to Botswana in 2000 caused excitement as this stood as a reminder that long after scientific racism had been discredited, its legacy was still alive in a lot of European museums. The teacher used this example to illustrate the use of C-14 isotopes in carbon dating and even in solving mysteries of the past.

In my view the analogies and the stories seemed very helpful and relevant. For instance linking the mathematical expressions and electron loss/gain where the teacher made deliberate link between the two. Some of the examples, however, did not seem to have a strong link to the concept he had been trying to illustrate. For example, the link between El Negro and the C-14 isotopes was not made apparent to the students. He did not mention explicitly whether the age of El Negro had been determined through carbon dating, but seemed to imply that. Students seemed to enjoy the story although it was already familiar to most of them. The intention of telling the story was to show students the application of isotopes, but the concept was left hanging.

Nature of Interactions in a Triple Science Class

Teaching a triple science class seemed to require a different approach from Mr Mpho. He employed various methods aimed at challenging the students cognitively and the learners were highly motivated and always active. For instance, when the teacher was away from school on two occasions and thus not in the classroom the students were seen to be studying on their own. The learners were either reading, or engaged in problem-solving activities individually or in small groups. The students did not waste any time as all their talk was related to the tasks they were engaged in. During his absence, he swapped his form four double class lessons with other subject teachers, but he did not do this with the triple science group.

When Mr Mpho taught topics like displacement reactions, reactivity of metals and electrolysis there was always practical work involved. For example the final lesson in teaching electrolysis involved demonstrations illustrating the electrolysis of water and electroplating of copper. There was a lot of engagement by students as they electroplated various metallic items brought by the teacher, or which they had brought themselves (such as a key, spoon, ring etc). Discovering that electroplating gave a rough and uneven surface created a lively atmosphere as they wondered amongst themselves why it happened that way.

Another topic taught in this class was displacement reactions, where the teacher discussed new concepts by linking the topic with topics previously done like redox, the reactivity series, extraction of metals and displacement reactions of halogens. The lesson topic was later finalised with a practical session where the teacher first performed a demonstration to help guide the learners who later did the practical in small groups of 4 to 5 learners. The practical work generated a lot of excitement while learners were performing the experiment. This seemed to suggest that the practical tasks were mentally engaging and stimulating to the learners, promoting inquiry.

Mr Mpho also attempted to relate some of the new material covered to other topics. For instance, during the topic displacement reactions the teacher explained how these concepts could be useful, for example, it would be possible to prepare or convert one compound to another if one wanted to. He said,

> Another is the one you use at the hostels… an element of kettle accumulates calcium carbonate, and you can decompose by heating… what is left is calcium oxide… and calcium oxide reacts with water to form calcium hydroxide which can easily be dealt with…(W2D3 Mpho, pg 4).

This example was used with the triple science class and they easily made connections about how this could solve the problem caused by hard water. Mr Mpho regularly used context-related representations or analogies, because he regarded them as making concepts more understandable. Talking about the use of well thought out representations such as analogies and application examples, Mr Mpho said,

> …for example ….when I am teaching the 4x (triple) it didn't take that longer for them to understand... now this double science (4y) … in most cases that is what I do (use analogies), if I use them or I use something that they can see with their

> naked eyes… because it seems to…be coming closer to them than when it is just on the board. *Gone* in most cases they do understand if it is in that sense, when you are using a practical thing you see, like when you are using the students themselves…. (Mpho interview Page 3)

The contexts introduced in this way were able to bring relevance of concepts that had appeared distant and confusing to learners. In this way learners were able to use concrete examples to understand abstract concepts.

Summary of Mr Mpho's Teaching

Mr Mpho varied his teaching approaches depending on the stream he was teaching. This became apparent when he was teaching a triple science class compared with teaching a double science class. Triple science students were offered more opportunities to engage in lessons as well as more opportunities for hands on activities.

A dominant teaching approach to engage learners was the use of class exercises which students worked on individually or in small groups. The teacher mainly acted as a facilitator to those who sought help. Lessons were generally made more understandable by contextualising content, or by using representations and analogies to help learners understand. Practical work was given to consolidate understanding for most of the content covered.

Language seemed a problem with the form fours, but this did not discourage them from standing up and talking or asking questions during class discussions. Learners struggled to clearly express themselves when responding or asking questions, but the teacher seemed good at picking what the learners meant even though the questions were at times not clear. Since learners were not first language speakers of the official languages Setswana and English, the teacher did not alternate between languages as he understood change of language would not help. Instead the teacher used a lot of examples and analogies to help learners grasp concepts.

Some problems with Mr Mpho's teaching were observed. For instance, the form 4 class appeared tense when lessons were held in their base room where the teacher would cram them into the front of the classroom. This could have been done to exert

maximum control over the students. Learners always appeared reserved when in their base room, asking fewer questions, but still responding to questions well and going to the front participate in demonstrations.

The teacher also searched for prior topic knowledge from learners, but there was a tendency to ignore the responses. For instance when asking about the test for hydrogen gas, which he said they learned during junior studies, many answers like using limewater, burning or glowing splint test could be heard. And when asked about test for alkalinity, the teacher did not take blue litmus *turning* blue or blue-black responses seriously. He merely brushed aside wrong answers treating them as unimportant. However, Mr Mpho used feedback from homework to inform the introductions to his lessons.

Generally Mr Mpho had large teaching resources to draw from, using a variety of methods such as use of practical work, and a variety of examples in the form of stories, analogies and application of science. This seems to suggest that Mr Mpho had a wide pedagogical knowledge to draw from. His knowledge of learners' limitations with language also helped him to prepare well, in terms of finding good representations, examples, analogies and practical activities to consolidate learners' knowledge.

8.3.3 Classes Given by Mr Sunny

Mr Sunny's preferred teaching method closely resembled Mr Mpho's. He used discussion-oriented lecturing methods, engaging learners through prompting and probing questions. He also gave brief notes (in point form) as he taught. His two form five classes (double and single) were generally very quiet during teaching, but were not shy when responding to questions mainly during post-test discussions. Mr Sunny generally thought his students were not bright enough to cope with the concepts and were docile because they were taking single and double science streams. He thought that more curious students were found in the triple science streams.

Nature of Interactions in a Double Science Classes

There was generally a low mental engagement in Mr Sunny's classes, and it seemed to me that minimal use of mental and hands-on activities caused a lack of interest and

problems in understanding for the learners. The excerpt that follows shows the result of failing to engage learners. Mr Sunny was teaching a form five double science class when he stated: '*…you are sleeping there… sit properly or you will sleep*' (W2D5 Sunny, pg 2), referring to some students who had their heads leaning on table tops. On another occasion when teaching 'reaction rates', he wanted the students to contribute by commenting on the reaction equation written on the board:

$CaCO_3 + HCl \rightarrow CO_2 + CaCl_2 + H_2O$

T: So how can we measure the rate of the reaction here? (No response)… if you were to carry out an experiment here what did we say we can do? (Still no response)…
T: The rate at which the reactants are used up
…but what is the most convenient (method) to use here
S: the reactant
T: which one and how? I am surprised, I don't know whether I am surprised or shocked …, any way we can measure the rate at which carbon dioxide is being produced… Which one do you think will be 'more' faster to react…and why? (No responses…) (W2D5 Sunny, pg 2)

Introducing concepts in this way did not seem to fit the teacher's idea of '*carrying out an experiment for every topic that requires one' (*Sunny interview, pg 2*)*. The students appeared to be uninformed about how rate or volume of production of a gas could be determined, but Mr Sunny did not organise any experiment to illustrate this. He seemed to favour whichever teaching method enabled him to complete the topic fastest. Mr Mpho, like his colleagues had a similar problem:

> …people want to complete the syllabus …So people are running after time… it's one or two where you find … instances where we give students practice (Mpho interview, pg 8)

Nature of Interactions in a Double Science Class

The double science class taught by Mr Sunny was a form four class. Learners were always willing to participate in class. They responded to questions and raised questions, showing that they were following what was illustrated. For instance, one learner on realising that Mr Sunny was inconsistent in using 'N' and 'n' to represent 'neutron number' questioned the inconsistency. Having been told earlier that mass numbers of atoms are always whole numbers, another learner asked why some atomic masses they met in homework like chlorine (35.5) were fractions. The dialogue that went on highlights this:

S: You said there are no decimal numbers in mass numbers ….
T: Where did you see it?

S: In the textbook.
T: This is actually not the atomic number, but relative atomic mass… (The teacher also talked about isotopes and said it is an average) …but we will talk about it later …there are very few elements which exist as atoms with same number of neutrons and mass …and we do not have half proton and neutron…but so only have full mass numbers… (W2D5 Sunny, pg 1)

During the interview Mr Sunny said he did not think that the classes he was teaching were inquisitive enough nor that they could ask intelligible questions, saying:

> …no…maybe it's because I am teaching the double and the single (classes), maybe the triples I think they will get such questions… (Sunny interview, pg 3)

His perception of his classes seemed to influence his preparation for lessons. For example, Mr Sunny was at times caught off guard with (problematic) challenging questions coming from these learners. The dialogue that follows involves a learner, who wanted to know whether inner shell electrons have any function:

T: …Aah… (Thinking)…they are just like the protons or the neutrons... are you asking for atoms in general or in chemical properties?
S: What are the functions of electrons in an atom in general?
T: …Mmmh… Any? Ga dina tiro! (They are of no purpose)…whether you remove there will be no change… it (atom) will still be the same.
S: It's not the same.
T: What is the function then?
S: To provide energy for the atom.
T: That's his view… also responsible for the stability of that atom…like we said for an atom to be stable, there has to be some electron…but the outer shell…so they have a function! (W2D5 Sunny, pg 3)

This showed that learners were indeed able to initiate questions to propel the discussion about science further, even though Mr Sunny was forced to admit that he did not know the answer.

Mr Sunny was the only participating teacher not to have offered a practical session during the study period with the classes observed. To some extent the lack of hands-on activities and the kind of responses Mr Sunny gave, revealed that he could not answer questions because he had not studied the topic well enough. This confirmed what he had said about his lesson preparation. The depth of preparation seemed to be linked to his attitude towards the classes he was teaching. As a relatively new and inexperienced teacher in this school, he had only been allocated single and double science streams and his perception that single and double science classes are generally weak meant he came to class under-prepared. He did not seem to have purposefully

considered what it was that he wanted to communicate to the learners and how this could best be done, taking the background knowledge of learners into account.

Summary of Mr Sunny's teaching

Mr Sunny taught lower ability classes, the double and single science classes, but only the double science classes were observed. According to the observations, he did not use a variety of teaching methods. His preferred method resembled lecturing, which he made interactive by asking learners questions, and having learners work on class exercises and homework tasks. Homework activities helped the teacher to gauge student difficulties.

Learners in the double science form five classes did not react much to Mr Sunny's invitations to participate. The form fours double science learners on the other hand seemed livelier as they challenged the teacher with questions he did not expect. Mr Sunny therefore appeared to have limited knowledge about SMK his and his learners and seemed not put a great deal of thought about them in the preparation.

The questions he asked and responses he made seemed to show that the teacher generally came to class prepared just enough to cater for what he perceived to be limited ability students. On several occasions it was clear that the low level of his lesson preparation was inappropriate for the important concepts to be taught or to handle the questions asked, even though his classes were double science and not triple science learners. He seemed to underestimate his learners assessing them to be less curious and not able to engage or ask challenging questions.

Mr Sunny's seldom used contextualisation and analogies to get concepts across. The teacher was not observed carrying out any practical activity. During the interview he mentioned that the science department reserved practical activities for triple science students. He attributed his limited use of practical work to constraints faced by the chemistry section such as lack of apparatus, large class sizes and language problems of learners. There were also missed opportunities to introduce practical sessions or use analogies during his lessons, which might have helped with understanding of concepts. He thus limited students' learning chances. For instance, when he talked

about ways of measuring and collecting a gas from a reaction, students appeared lost but he did not intervene by using a more practical approach.

Because the importance placed by the BGCSE curriculum on practical work, this will be discussed separately to the normal teaching activities.

8.4 Hands on Activities – Practical Work

The chemistry curriculum places emphasises on investigation and experimental skills acquisition. Learners are to develop various associated skills while conducting an investigation or carrying out an experiment such as being able to:

- Follow a sequence of instructions
- Handle instruments, apparatus and materials safely
- Make and record observations, measurements and estimates
- Interpret and evaluate observations and data
- Plan an investigation and evaluate methods
- Convert acquired skills into creative innovations

(Curriculum Blue Print: Republic of Botswana, 1998)

Observation data was used to find how the different teachers' interpreted and handled practical work in their teaching.

8.4.1 Experiments Observed

Results of interviews with respect to practical work showed that this was the most obvious and familiar form of activity-based learning to teachers at Maru SSS. The teachers talked about practical methods being encouraged by the curriculum and enforced by the science department. For instance Mr Sunny has been described as saying about the high expectations to give practical work for '*every topic that requires one' (*Sunny interview, pg1). He also said a demonstration by a teacher should be the minimum requirement for a lesson if it was not possible to carry out individual experiments. It was therefore expected that a lot of practical work would be observed. This is confirmed by the summary of observed experiments in table 8.3 below.

Table 8.3: Experiments carried out by Maru SSS teachers

	Experiments Performed	Class
Mr Bose	- Reactivity of metals with water and with dilute acid (demo) - Test for ions and Titrations - Preparation of salts	Triple Triple Single
Mr Mpho	- Electrolysis of water; electroplating of copper - Displacement reactions (metals) - Test for ions and titrations	Triple Triple Triple
Mr Sunny	None observed	-

Table 8.3 above shows that two of the three teachers carried out experiments fairly often. Other teachers, besides the three taking part in the study, also seemed to do a lot of practical work because it was common to see teachers or laboratory assistants organising material for experiments to be performed or washing apparatus. Although Mr Sunny was not observed doing any experiments, Mr Bose and Mr Mpho carried out three experiments each. One of these was a practical examination performed by all triple science students at the end of the semester.

Common features of all the practical work observed will now be described.

8.4.2 Common Features of Practical Work – Perceptions and Practice

The value Mr Bose placed on practical work is evident in both his stated ideas as well as his teaching practice. He said that he thought that knowledge gained from practical work was retained longer. He said, '*It (knowledge) does not get rubbed off very easily from learners' (*Bose interview, pg 2). Teachers generally viewed practical work as involving '*…letting students do the experimentation themselves… letting them observe'* (Bose interview, pg 2*)* and they '*should not give them too much leading information*' (Bose interview, pg 2). Mr Bose also thought that in order to enhance understanding, teachers should allow students '*at the end to discuss the observations'* (Bose interview pg 2). This seems to suggest that the teachers like Mr Bose had a view of practical work involving both the physical manipulation of the apparatus as well as some form of oral or written communication of what had happened during the experiment.

Mr Bose and Mr Mpho carried out practical work with their classes covering different topics, but following the same trend. The practical activities were always introduced after the content had been taught. This seems to suggest that the intention of the practical activities were to confirm theory recently taught.

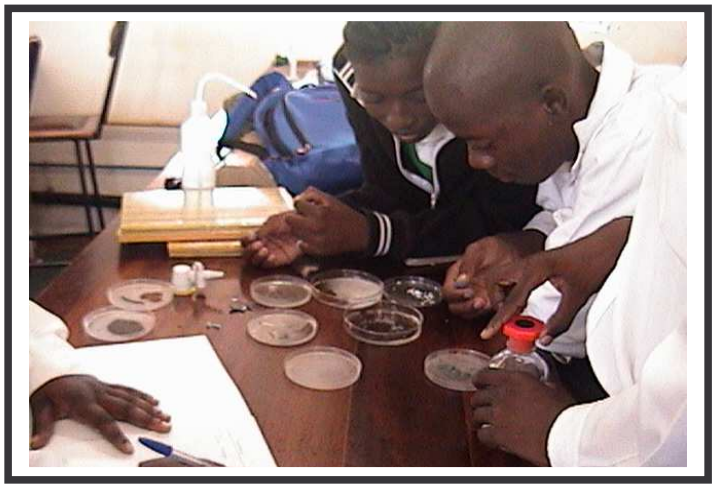


Figure 8.1: Students carrying out an experiment on displacement reactions at Maru SSS

When students carried out a practical on displacement reactions, this was done soon after completing the theory on displacement reactions in class. Students played an active role in the process of learning during the experiments. They were highly engaged in manipulation of materials and there was frequent communication between group members. This approach seemed to ensure that students' views of the facts learned in class were shaped through active engagement in practical activities. Students made use of the resources made available by the teachers to construct meaning, produce their own version of facts and concepts learned. Evidence from classroom observations seemed to show that students were accustomed to doing experiments. Students were also required to write down what their observations had been and to draw conclusions, in this case about the reactivity series.

The purpose of practical work did not seem to be the same for all classes. For instance, although Mr Bose did not reserve experimentation for the double classes, but also carried out an experiment with a single science class the main aim of the practical work was different. In the single science classes learners carried out the experiment in small groups, but the discussion that followed seemed designed to ensure that learners were kept motivated or occupied throughout the discussion rather than to enhance understanding. Mr Bose used the same methods with different purposes in all his lessons. It has already been described how the level of the discussion was regulated by Mr Bose to suit the perceived abilities of the particular class he was teaching.

Mr Mpho taught only the triple science classes through practical and his practical sessions followed the same pattern as Mr Bose's practical sessions for the triple science students.

8.5 Summary of Findings about the Teachers and their Teaching at Maru SSS

A summary of the teachers' perception of the curriculum changes and what teaching and learning meant to them is given in table below:

Table 8.4: Maru SSS teachers' perception about curriculum changes

	Content changes	**Assessment changes**	**Teaching and learning changes**	**Readiness to implement changes**
Mr Bose	Contextualisation Context brought relevance	Contextualisation of questions Context brought relevance	Learner-centeredness Discovery learning Experimentation Group-work	Ready
Mr Mpho	New topics/concepts added Contextualisation, relevance Positive & negative consequences	Contextualisation of questions Context brought relevance	Learner-centred Experimentation Group-work But chalk-talk dominate	Misconceptions about BGCSE methodology
Mr Sunny	Removal of topics Brought over simplification of curriculum	Number of papers introduced	Experimentation	Demands not realistic

The table above shows what teachers perceived to be the most obvious changes at policy level. These were to do with content of the syllabus, the assessment and teaching procedures.

- Teachers continued to make comparisons between the old curriculum and the BGCSE especially issues related with the topics or concepts included or omitted in the new curriculum. They generally showed preoccupation with topics or concepts that had been left out from the previous curriculum.
- Teachers saw changes concerning teaching and learning process as only having occurred at policy level without any changes in classroom practice where traditional approaches were still used. This did not seem to support the view of the senior (young) teacher that teachers were committed to the BGCSE methodology and principles at all times.
- The bulkiness of the new syllabus was seen as a hindrance to implementation, though some topics were removed, a lot more were added.
- The learner-centred teaching and learning demanded by the BGCSE (or activity-based learning) was mainly interpreted to mean practical work.

- Implementing of practical work was viewed as being constrained by classroom characteristics, time, and class sizes and to a small extent availability of resources. In addition student factors such as learners' science background, language and motivation to learn generally played a role.
- The assessment was seen as having contributed little in bringing change in teaching approaches but major/visible changes included
    - Improvement in the readability of examination question
    - Improvement in contextualising questions which makes them more relevant and understandable
    - Assessment demands especially to double and single science streams was not linked to teaching demands or more experiment work required

Teachers and Practice

Table 8.5 summarises what was actually seen happening in the classrooms of the three teachers observed. Indicators of practice included teachers' approaches and how teaching was accompanied by contextualisation and practical work. The summary also includes learner participation and treatment in chemistry classrooms.

Table 8.5: Maru SSS teachers' Teaching Practice

Practice	Mr Bose	Mr Mpho	Mr Sunny
Contextualisation and application	Highly contextualised through use of: Analogies; application of science/real life examples; use of stories		Rare
Teaching approach	Learner centred Group-work Whole-class discussions Regular homework	- Chalk-and-talk; regular homework - Prior knowledge search - Learner centred: group-work - Whole-class discussions	- Teacher-centred: with some degree of interaction - Regular homework
Classroom practical work/ demonstrations	Practical work - Demonstrations - Group experiments - Practical examination		Not observed
Treatment of Streams	Same treatment: in terms of experiments given - Nature of talk (discussion) different	Treatment different in terms of - Nature of talk - Exposure to more engaging activities	Different: - Viewed triple science as more curious and willing to learn
Learner Involvement and participation	High - discussions and argumentations during teaching, experiments & class discussions - Hands-on participation in experiments and homework	*High to moderate (mixed)* - Discussions & argumentations during teaching; experiments - Participation in experiments: along stream line Problem solving tasks common	*Moderate to Low* Limited discussions and argumentations during teaching Homework (problem solving tasks) common
PCK/level of preparations	Highly developed PCK Sloppy teaching single/double streams		Weak PCK Weak preparations Weak representations used
Teaching for examinations	Seemed the main aim		

The table summarises the practice observed from Mr Bose, Mr Mpho and Mr Sunny. Some points will be picked from the table including some not in the table.

- Preparation was generally satisfactory except for Mr Sunny who preferred to avoid practical work in his teaching approaches. Evidence for less preparedness also came from the struggle he faced in responding to some questions from learners.
- Mr Bose and Mr Mpho mostly attempted to help learners learn with understanding using a variety of approaches including contextualised illustrations and analogies. Mr Sunny only minimally contextualised content during his teaching.
- The poor language skills of learners was handled through use of a variety of approaches such as exercising greater patience to allow learners to put their points or questions across. Teachers were able to reformulate students' poor questions into questions that made sense before responding.
- There was a fair amount of practical work carried out at Maru SSS, although the single science stream seemed neglected. Only one teacher was observed doing experiments with single science students. It was clear that teachers thought that practical work was more appropriate for triple science students who have the pre-requisite background knowledge and skills to perform experiments. In these classes, numbers are relatively low and language is not so much a problem.
- Written class exercises and homework formed the basis of what they saw as feasible activity-based teaching as it allowed for less time doing class exercises.
- The inexperienced teacher had very poor knowledge of his learners, which made him to underestimate his preparations

8.6 Discussions of Findings for Maru SSS

Following the scrutinisation of Mr Mpho, Mr Bose and Mr Sunny, to determine the patterns in terms of classroom interactions and teaching it was possible to identify the operational levels for the school. Each teacher's current level of operation on classroom interactions, practical work and contextualisation was summarised based on their classroom activities. Individual teacher's teaching patterns eventually helped identify the ZFI for each teachers and the school.

DISCUSSING MARU SSS OPERATIONAL LEVELS

In order to draw the ZFI, it was necessary to first come up with a contracted table of the teachers' practices. Table 8.6 is a summary of indicators of what the teachers were doing in their classrooms, drawn from individual teachers practice as it related to classroom interactions, practical work and contextualisation of concepts.

Table 8.6: The Operational Indicators of Maru SSS Teachers

Name	Classroom Interactions	Practical Work	Contextualisation
Mr Bose *AND* **Mr Mpho**	Interactive lecturing/discussions Brief notes provided- in points form Use of additional sources of information for presentation notes Homework given regularly Monthly tests given Experimental examinations given *Minds-on activities and Learner engagement-Class discussions* *Practical work* *Demonstrations* *Meaningful and deep engaging questions & problem solving tasks common*	Practical work or demonstrations during lessons- both streams Highly engaging discussions reviewing practical work and demonstrations *Practical examination given:* • *Qualitative & quantitative aspects*	Teacher use contexts and application examples from everyday life and story telling Problem solving exercises/tasks linked to application of science
Mr Sunny	Chalk-and-talk dominated lessons Brief notes provided Engaging questions raised during discussions Minimal hands-on and minds-on engagement	No practical work or demonstrations observed	Minimal application of science and Linkage to real life (to illustrate concepts) during teaching

From the current practice it is possible to predict the levels of operation according to Rogan and Grayson (2003) guidelines. Detailed description of the translation of the indicators to operational levels was made in chapter 6. Table 8.7 shows the levels of operation for three teachers.

Table 8.7: Operational levels of teachers at Maru SSS

Name	Operational Levels		
	CI	PW	Contextualisation
Mr Mpho	3	3	3
Mr Bose	3	3	3
Mr Sunny	2	1	2
Average	2.5	2.5	2.5

The information above was converted into a bar graph. This way, it becomes easy to visualise the current practice as well as the possible ZFI for the teachers. Identifying the ZFI makes it is possible to predict the direction of growth anticipated for the school.

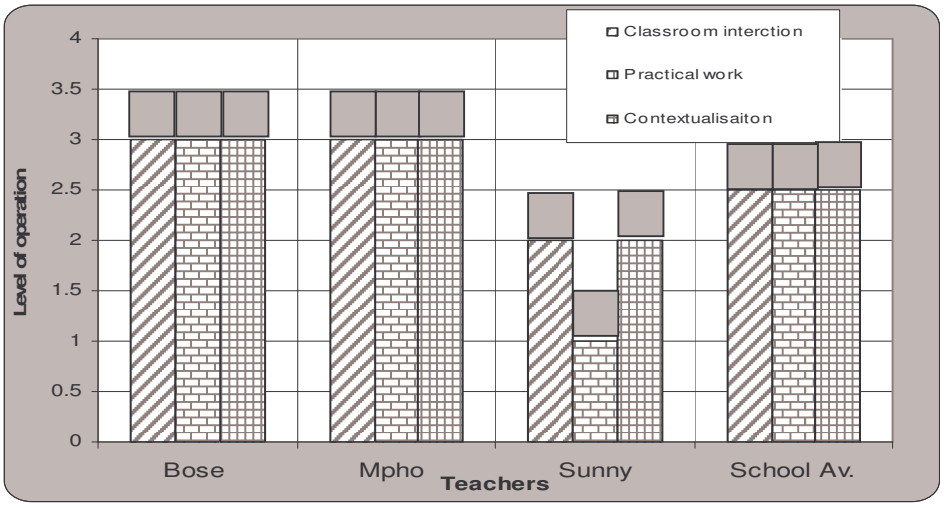


Figure 8.2: Maru SSS' level of operation

Figure 8.2 above seem to confirm that Mr Bose and Mr Mpho were head and shoulders above Mr Sunny in all dimensions. The above figure shows the level of operation of the teachers, the school, as well as the ZFI. Mr Mpho and Mr Bose appeared to do very well in terms of quality classroom interactions, practical work as well as incorporating aspects of contexts during teaching. Mr Sunny was generally low in all areas, which could be attributed to his lack of teaching experience.

Mr Mpho operated at level 3 on classroom interactions most of the time. Practical work formed part of his teaching repertoire as well as probing learners' prior knowledge, contextualising concepts, mixing various teaching approaches in problem solving activities. Though Mr Mpho brought all these strategies and learning opportunities for learners, the lack of balance between triple and single learners appeared to be a problem. He seemed to operate at lower than level 3 when teaching the double science stream. Another weakness was that some of the analogies he used appeared superficial or slightly out of context, and therefore needed to be explicitly linked with target concepts to enhance understanding.

Mr Bose operated at the same level as Mr Mpho on classroom interactions. Problem solving tasks were common in the form of classroom exercises and home work tasks, with highly contextualised questions. Mr Bose mixed teaching strategies in the form of group work, practical work accompanied by class discussions. But it was also clear with Mr Bose that the high level of attention and preparation given the triple science

learners was not extended to single science learners. Though he gave learners the opportunities to perform experiments, the quality of discussions that went on was lower with single science classes. Learners were not expected to reason deeper, instead Mr Bose accepted less worded responses and expanded them without probing.

Mr Sunny operated at level 2 in his handling of classroom activities. As one of the least experienced teachers in Maru SSS he was teaching only the single and the double science streams. Though he attempted to incorporate discussion into his lesson, he seemed less prepared as he generally perceived the single and double science classes as less inquisitive or interested to learn. This limited the depth of talk occurring in class. His perception about single and double classes compromised his preparations for the classes. A result of under preparation was seen when he appeared less prepared to respond to certain issues students raised in class. Preparation was to him identifying the learning objective, having some content notes put together. There appeared not to be much thought concerning delivery, or broader issues Loughran et al. (2006) refer to as curricular saliency, what the teacher need to know about the concept which does not have to be part lesson yet. According to them, a teacher needs to have a good knowledge about his students which influences the way of preparations (Loughran et al., 2006). The attitude towards low ability learners seemed to block the teacher preparing extensively as he did not perceive his learners as capable of challenging the knowledge he put forward.

The table also shows that generally Mr Bose, Mr Mpho and Mr Sunny had a homogeneous approach to teaching as shown by the type of teaching approaches they employed.

All the information above about the current practice makes it possible to identify the ZFI for Maru SSS. An amalgam of the levels of operation of the teachers had been used to come up with a single operational level representative of the whole school. This seemed to make sense as it ties up with what was observed to be the case in classroom practice.

From the figure 8.2, it could be deduced that teachers collectively operated at lower levels (2.5) in terms of classroom interactions, practical work, and contextualisation

of concepts than were individually observed teaching. The figure seems to confirm the classroom observations especially from the experienced teachers who appeared to do very well teaching triple sciences, but also lowered their standard when teaching the double and single science streams. Low levels of operation in CI, PW and contextualisation were also observed in Mr Sunny's classes.

The result has several implications in terms of whether teaching and learning can be considered as learner-centred in this school, equitable and balanced to all chemistry learners. From the identified ZFI of Maru SSS, several deductions can be made concerning the nature of collaboration or cooperation by the teachers and areas that need improvement and therefore be targeted for professional development.

Strategies Needed for the School

From figure 8.2 it was clear that the teaching patterns between the three teachers were homogeneous. But what the figure does not show is that teachers treated learners differently.

- Learners who took triple sciences mainly received quality teaching in terms of high level of interactions with the teachers and peers, involvement in minds-on and hands-on activities.
- Though two teachers were operating at higher levels it was observed that even at lower levels 1 and 2, there were areas where teachers still needed to improve such as preparation for lessons and engaging learners more meaningfully.
- For the less experienced teacher, he appeared to struggle to find suitable illustration or use context based examples or analogies to make concepts more vivid. Practical work was not observed in his classes during the period of observations. These were areas that needed to be improved to make the level more solid.
- For all the three teachers, it was clear that even lower levels were not well set. This has implications for professional support in this school targeting balancing of resources as well as time devoted for learning by the single and double science streams as well as raising levels of operation across teachers and streams.

Chapter Conclusion

The three teachers Mr Mpho, Mr Bose and Mr Sunny's classroom patterns had been discussed modelled under the theory of implementation by Rogan and Grayson

(2003). This helped to identify what could be described as the current operational level of the Maru SSS as well as the ZFI for this school. The current practices, as well as the ZFI have several implications concerning steps that could be taken for the school to move forward in improving its current patterns of teaching. Classroom interactions, contextualisation as well as science practical work were found to be satisfactory in some areas, but there were areas that needed to be improved concerning individual teachers and chemistry teachers as a whole. This included:

- The need to polish levels teachers were already operating at. There were still some concerns over issues teachers took for granted and considered them as unimportant such as balancing teaching across all streams
- Attempt to help all teachers at relatively lower operational levels to raise to higher levels already attained by colleagues and
- Attempt to move to new levels which basically means trying new things, teachers have never attempted such as classroom interactions, practical work and science and society at level four.

CHAPTER 9 LESEDI SSS

Introduction

As in the previous chapters, this chapter will start by outlining teachers' perceptions about the nature of curriculum change and demands of the curriculum. This information was obtained mainly through interviews. The chapter goes on to describe the general classroom activities of each of the three teachers. Because of the emphasis of the new curriculum on practical work, this will be discussed separately from the normal teaching. Finally the chapter will summarise what the status of Lesedi SSS was in terms of Rogan and Grayson's (2003) theory of curriculum implementation and endeavour to ascertain what the ZFI for Lesedi SSS was at the time of the study.

9.1 Teachers' Profile

Before outlining the results on teachers' perceptions about the curriculum changes, the teachers' profiles will be revisited. Ms Nakedi and Ms Bolaane both possessed Bachelor in Science Education qualifications. Having been on the field for a relatively long time, they both taught all the chemistry streams. Ms Bolaane had a passion for the subject 'Guidance and Counselling' and therefore offered the subject to learners as an optional non-examinable subject. The two teachers were observed seven and eight times respectively. The third teacher, Mr Kopano possessed a BSc in chemistry and geology. According to him, not finding work in industry forced him to take a Postgraduate Diploma in Education (PGDE) in order to gain the necessary qualification to teach senior secondary school chemistry.

Table 9.1: A summary of Lesedi SSS chemistry teachers' pedagogical profiles

Pedagogical approaches	**Nakedi**	**Bolaane**	**Kopano**
Lecture method	1 (T)	5 (T/S)	6 (D/S)
Whole class discussion	-	2 (T/S)	1 (S)
Group discussion	-	1 (T)	-
Experimentation (teacher demo)	-	-	-
Experimentation (Learner)	1 (T)	-	-
Learner Presentations	4 (T/S)	-	-

The teachers' perceptions about the chemistry curriculum and what implementation meant to them was explored.

9.2 Teachers' Perceptions about the Curriculum Changes

Only results from analysis of interviews of how the chemistry teachers perceived the BGCSE curriculum changes and implementation have been used in this section. The various issues they talked about were grouped together into three domains relating to the content of the chemistry syllabus, assessment and teaching and learning. Each of these will now be explored further.

9.2.1 Changes in Terms of Chemistry Syllabus

Changes in terms of content was taken to include views about the topics in the new syllabus as well as perceptions about adequate levels of treatment and the relevance of the new curriculum.

In Ms Nakedi's view the curriculum had changed a great deal in terms of chemistry content. She said the most observable changes had been the introduction of '*new topics like the silicon and food preservation methods' (*Nakedi Interview, pg 1). She viewed the content related changes in the curriculum as having been mainly addition of subtopics and new teaching objectives to those already existing. On the other hand, the relatively new teachers Ms Bolaane and Mr Kopano could not describe in detail what the changes in chemistry content had been, instead preferring to talk about what seemed to them to be the most observable changes which had taken place in terms of teaching and assessment approaches.

Besides changes in content, Ms Nakedi said that the emphasis placed by the new curriculum on the contextual application of science was extensive:

> …every topic has an application of everyday lives… like things we've been talking about (in class), examples of commonly occurring names, which involves a factor… like food preservation method… which was not there in the Cambridge (Nakedi Interview pg 1).

She also thought that in teaching every topic the content required contextualisation, for instance associating concepts with applications of chemistry and also stressing the connections with day-to-day life situations. She thought that this had had a negative impact on teaching. Bringing in new topics and the need for stressing application of chemistry and nature of science had broadened the syllabus. As a result she generally

struggled with time to complete the syllabus. The high teaching load had also meant that the focus towards learner-centeredness had failed to take off in her teaching. The objective that learners should control the pace of teaching, according to her was not occurring as covering the content was still the main thing. She thought the double science stream had been more affected than the triple science stream as content is more or less the same in both streams while the triple science has more time:

> …for the double awards, we struggle every year to finish. The syllabus is almost… every topic in the separate (triple) is there in double award, but the time is shortened (Nakedi interview- pg 1)

9.2.2 Changes in Terms of Assessment

Another view of the curriculum change included changes in terms of assessment procedures. Ms Bolaane and Mr Kopano had strong views about assessment related issues with Ms Bolaane viewing the grading system as being totally transformed. She thought the changes had been so drastic that parents and even some learners had struggled for some time to know how to interpret the new system:

> …like we are using the point system, we were using aggregates, so the point system is different, and it's a little bit different to understand from what we are used to…(Bolaane Interview- pg 1)'.

Mr Kopano's views about changes were that assessment standards have been lowered as things had been made easier for learners. Despite lowering standards, he thought learners continued to fail tests and examinations:

> *…it appears like … the present grading has changed…things look more simplified' (*Kopano interview, pg 1).

The more experienced Ms Nakedi's views were focused on the number of improvements made for the single and double science streams. She said about the old curriculum:

> …we didn't have any paper 4… they were not assessed on this practical work, but nowadays they are being assessed on practical work... (Nakedi interview, pg 3)

Though the teachers were aware of the introduction of an examination paper based on practical work for the single and double streams, it was interesting to see that the teachers did not necessarily see it as necessitating the alignment of teaching the single

and double science streams in a way that would give the learners exposure to practical work. Desire to cover more content remained the priority.

9.2.3 Changes in Terms of Teaching Practice

The teachers' views about teaching and learning included what they considered to be the requirements of the new curriculum about meaningful, effective teaching, as well as the overall position of the new curriculum concerning activity-based teaching and learning. All the three teachers acknowledged that the curriculum had changed in that there was a demand that teaching be done differently from traditional approaches. For example, Ms Nakedi said,

> Now the syllabus requires learner-centred approaches. That we should carry out experiments for every topic that requires an experiment (Nakedi interview, pg 1)

Ms Nakedi and her colleagues held similar views in that the BGCSE methodology also viewed as learner-centred teaching, meant mainly use of practical work. Interview results showed that Ms Nakedi also knew of other ways to engage learners. She thought the difficulty she encountered in using practical methods had resulted in her employing information searches and classroom presentations to involve learners. She said of the presentation activities:

> …the fact that learners go and research and come and try and present in class I take it to be part of the learner-centred [approach] (Nakedi interview, pg 2).

Her view was that for the teacher to not interfere too much was key to the success of this method. If:

> …you are a facilitator, you must provide information where necessary… the learners come up with that information, and you have to help where it is necessary (Nakedi interview, pg 3)

Ms Nakedi said she ensured that learners had enough time to search for information before their presentations, but she left the door open for those who would need guidance during their research:

> I ask them that if they have any problems they can come back to me (Nakedi Interview, pg 3).

Ms Bolaane was also able to differentiate between the old and new curricula in terms of teaching and learning:

> …Nowadays, the learners should have an input, a lot of input into their education system, because that's what should happen (Bolaane interview, pg 2)

Mr Kopano viewed this kind of demand as not practical. He thought that methods involving engaging learners are too '*theoretical'* (Kopano interview, pg 3). This was especially true with activity-based learning which he and his peers viewed to mean teaching that involved "*use of experiments and the demonstrations' (Kopano interview, pg 3*).

Ms Bolaane also raised the issue of ownership of the demands of the new curriculum. She viewed the changes as something that was "out there", valued more by the curriculum developers than by the teachers. Interview results also revealed that she did not value the learner-centred methods as part of her teaching repertoire. In fact she did not relate them with learners' constructing their own knowledge. She instead talked about student-directed modes as having appealed to her more during her pre-service training. Having given her best during the training, she no longer saw the need for a variety of approaches. She said,

> It is different because there you will find that you employ different kind of methods… (Bolaane interview, pg 3)

At the time of the interviews the teacher thought that teaching effectively involved just "*marking and giving out assignments, test and quizzes'* (Bolaane interview, pg3). All these had nothing to do with the activities that engage learners either hands-on or mentally to help construction of new knowledge. Ms Bolaane still used traditional methodologies as she spoke about good teaching involving "…*to teach*" accompanied by the tests, quizzes as the only way to ensure learners stay focused.

9.2.4 Perceptions about the Readiness to Implement the New Curriculum

Ms Nakedi and Ms Bolaane thought that they were adequately qualified for them to handle all the demands of the new curriculum. However, the less experienced Mr Kopano thought he lacked the knowledge to implement the curriculum. He associated his deficiencies in teaching well to lack of exposure to certain methodology courses during his training which had narrowed his growth in pedagogical content areas. For instance he indicated that he had difficulty accessing learners' prior knowledge. He

indicated that these limitations made it difficult to gauge how much knowledge learners had gained in lower grades:

> since I started teaching the form fours, especially the topics which I believe have been taught before, that's where I have that kind of problems, because I don't know where to start …I have a problem of how to approach the topic, because I always have the thinking they have the background information, and then I am not sure how much of the information they have, and then the approach becomes problematic (Kopano interview, pg 3)

According to Mr Kopano, he was unable to source knowledge from previous activities to prepare and guide learning processes. Literature reveals that low PCK in teaching certain topics can be expected when teachers are teaching new topics, especially when novice teachers are involved.

9.3 Implementation of the New Curriculum in Classrooms

The results from the interviews showed that teachers certainly had an awareness of what the aims of the BGCSE curriculum were, primarily viewing the BGCSE as demanding an increase in hands-on and mentally challenging opportunities for learners. As summarised in table 9.1, different teachers favoured different instructional approaches. Ms Nakedi favoured inquiry and presentations, whilst Ms Bolaane's lessons were dominated by more interactive lecturing lessons. Mr Kopano's lessons were dominated by mainly lecturing.

During the interviews teachers expressed more or less similar views about what the curriculum demanded, stating that performing experiments was one of the main requirements of the new system. Teachers were aware that learners themselves were supposed to do the experiments, however, all thought it was not a practical approach to use in their school. Instead, they said they preferred to use the methods they, the teachers, were comfortable with irrespective of whether they were learner-oriented or not.

In addition to gleaning teachers' views from interviews, classroom observation data relating to teaching was also used to identify approaches adopted in chemistry classrooms as well as the type of teacher-student interactions in classrooms.

Each teacher will be discussed individually to explore evidence of successful implementation of the new BGCSE curriculum as well as to identify links between what they said they did and what they actually did. The teaching repertoire grid for the Lesedi SSS teachers presented in table 9.1 gives a summary of teaching methods as well the number of times the methods were used in teaching chemistry. For example, Ms Nakedi's were highly engaging in terms of learners searching for information and involvement in communicating and argumentations during presentations. The other two were involved but to a lesser degree. The teaching approaches used by teachers were used to piece together a picture of how the teachers conducted their lessons, and how much they engaged their learners.

9.3.1 Lessons Given by Ms Nakedi

During the interview Ms Nakedi indicated that curriculum had changed significantly in terms of content, and also in terms of teaching and learning approaches. She mentioned that teaching and learning now required a move away from the formerly predominant lecture-method to more learner-centred methods of teaching. According to her, instructional approaches like using a lot of examples of application of science were supposed to engage learners during teaching. She said this could easily be met by the use of experimentation. However, due to certain constraints, she considered it difficult to employ experimentation. Ms Nakedi was observed seven times teaching form five triple and single science classes. She was the only teacher who realises that there are other learner-centred methods.

Ms Nakedi's most favoured methods were learner-presentation sessions and whole-class discussion sessions. These strategies had interesting components in that learners were given many opportunities to engage with the content, with the teacher 'facilitating'. Ms Nakedi viewed the way she allowed learners to present the lesson as offering learners the opportunity to be involved taking part in shaping their teaching and learning. According to Ms Nakedi, a learner would take a topic home to go and research individually. Her perceived intention was to give learners an opportunity to improve their inquiry and communication skills. Ms Nakedi would start by allocating learners subtopics to go and research, using some ex-learners notebooks, the library

and recommended textbooks as sources of information. Learners made detailed notes in their notebooks during their inquiries to facilitate their presentations in class.

Four such presentations were observed, carried out by two classes she taught involving the topics:

Table 9.2: Classroom presentations by Ms Nakedi's Learners

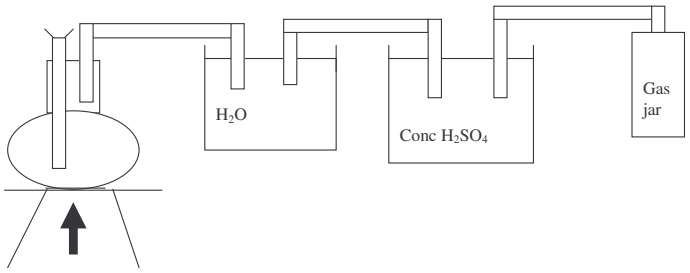
	Topic	**Task**	**Time allocation**
1	Preparation/composition of alloys	Reason for making alloys and uses of alloys.	40 min
2	Chlorine (non-metals)	The presentation was based on preparation of chlorine, test for chlorine, properties (physical and chemical) and its uses.	40min
3	Reaction rates -	Effects of concentration on reaction rates	20 min
4	Reaction rates -	Effects of temperature on reaction rates	20 min

Nature of Interactions in a Triple Science Classes

Observations showed that the presentations seemed to challenge learners' research abilities, communication abilities as well as linguistic confidence. Learners generally struggled with use of English, hence most learners in her class preferred to use Setswana, as depicted by the excerpt below:

> $S_{presenter}$: Tsatsi jeno keya go presenta ka... (Today I am going to present on…)
> Learners: Boa ka sekgoa (they said in large numbers, but even when they called on her to change language she could only say more in Setswana, the other mates were telling her in Setswana to present in English)
> $S_{presenter}$: Ke ya go lo presentela ka presentation ya Chlorine…chlorine can be prepared from $Mn_2O_4^-$…and also… NaCl ….I have chosen the one from…concentrated HCl oxidized with MnO_4^-… we put MnO_4^- into a flask… <and before she continues one says>
> S: Which flask… (she does not hear but she continues to say)
> $S_{presenter}$: …you pour concentrated HCl …connect …she now says 'let me show you a diagram to show this…this is the flask …and tse ke tsone di-bottles tse ke neng ke bua ka tsone tse [and this are the bottles I was talking about]…I don't know what they are called… (W2D2 Nakedi, pg 1).

English was only used for certain key and scientific words. The excerpt above shows how a learner introduced the lesson. She struggled to find correct names for apparatus used in her drawings (for preparing chlorine). The mix of languages also seemed to distract other learners as they attempted to force her to change language. The learner drew a simple diagram to enrich her presentation, to help clarify the process of preparing chlorine gas.



(W2D2 Nakedi, pg 1)

She called flasks and other glassware in her preparation diagram 'di-*bottle*' (W2D2 Nakedi, pg1). Struggling to use proper drawings and names for apparatus, however does not imply that her presentation was ineffective or that she had difficulty understanding key issues in her topic. The content of her presentation appeared well researched and language limitations did not discourage peers from contributing through asking questions or making comments. There was a lot of interaction between learners as well as between the teacher and learners with the teacher intervening at a certain point.

The triple science learners were generally very lively and made interesting contributions during presentations. Their contributions were mainly positive during other learners' presentations, but their comments were at times viewed by presenters to be disruptive or as personal attacks. The teacher did not intervene in most cases when a presenter's preparedness or patience was being tested. For example, one of the presenters stated that one of the uses of chlorine was as a '*weed killer' (*W2D2 Nakedi, pg 2*),* which was mistaken by one listener as '*fertiliser*'. This learner's request for clarification as to whether chlorine was used to make 'fertiliser' was met by snapping and almost fighting back by the presenter who said '*I never talked about fertilisers' (*W2D2 Nakedi, pg 2'. The teacher allowed emotions to flow without much interruption.

There was a lot of interest from learners in all presentations, shown by many questions asked. Generally, thought-provoking questions were generated and directed to the presenters such as '*Is hypo-chlorous the same as JIK?'* (W2D2 Nakedi, pg 3*)'*, a trade name for one of the locally sold stain remover. One girl was asked to illustrate how the substance removes the red or blue colour of the red litmus paper or when there is a stain… she demonstrated at the board writing a reaction equation: $Cl_2 + HOCl \rightarrow HCl + H_2O$ (W2D2 Nakedi, pg 3*)*

The same trend was observed in the other presentation on alloys, where learners wanted the presenter to inform them about the effect of percentage ratio of metals on characteristics of alloys and also the effects of having metal-metal or metal-non-metal combinations in an alloy. Learners made contributions and asked questions that engaged with context and chemistry ideas and to some extent this showed that learners had a broad knowledge about the topics.

Nature of Interactions in a Single Science Class

Single science learners performed two presentations on '*Factors affecting reaction rates*'. Their presentations were shorter, performed minutes after each other. It was during single science learners' presentations it became clear that presenters did not seem to have a lot of depth in the subject-matter. The teacher facilitated more frequently as learners made only brief statements about concepts. She encouraged learners to get involved by asking a lot of directed questions. The teacher was more or less the main contributor, as the learners appeared ill-prepared. This confirmed what the teacher had said during the interview that:

> I do try it with the single science, but the only problem with them is they are dull. They don't do their assignment, they don't do their assigned work… and even their presentations they are just going to read, they will just take the note book, from the ex-learners then they copy the notes, and then they bring them to class…not even an attempt to try and explain (Nakedi interview, pg 2)

It was clear that learners had language difficulties when they presented or tried to make sense of the concepts. Battling with both understanding and articulating what they meant was witnessed when learners tried to find the meaning for certain key words mentioned in the presentation. For instance the word 'concentrated' seemed to bring difficulties with understanding. One learner had to translate this to Setswana '*go tupela*' (W2D3 Nakedi, pg 2), and then putting it into context, relating that to '*sugar*' or '*orange squash' (*W2D3 Nakedi, pg 2) as concentrated. To further clarify the concept of concentration, especially as it related to reactions, Ms Nakedi had to take over from the presenter. She gave a mathematical example on proportions. Learners displayed poor mathematical skills by saying things like '*…if 10 g contain 2 particles, then 10 kg would contain 4'* (W2D3 Nakedi, pg 2) particles. The teacher assisted, converting the word problem into a symbolic representation and did a few calculations to clarify the

mathematical concept of proportion and concentration. To help bring understanding, she further consolidated by use of another contextualised example of people confined in a fixed space. She said:

> It's just like if I take 2 of you cover your eyes, and ask you to run around, what is the chance that you will hit one another, but if I take 100 of you, and blind fold you, and ask you to run around… (W2D3 Nakedi, pg 2)

Learners seemed to understand the analogy and easily related it to collisions and reactions.

Another student who presented on energy, preferred to ask questions as to why increasing the temperature increases the rate of reaction, directing questions to his peers. Varied answers such as particles '*expanding*' or '*vibrating' (*W2D3 Nakedi, pg2) were given. The teacher picked out certain concepts and expanded on the concept of vibrating particles, using analogies. Placing the reactions into familiar contexts seemed to help learners to relate the concept of energy, concentration and collision, bringing understanding.

> they become more energetic, if they were vibrating they vibrate more, they have more energy, at a lower temperature, they move slower, and at high temperature, they move faster and the collision will be faster (more)…I always give examples of cars. Slow cars are like colder particles, and when a car moving at 200km per an hour, and the others at 20, which one will there be more impact (during accidents), will there be any survivors? (W2D3 Nakedi, pg 2)

During the interview, the teacher talked about use of analogies and examples from day to day life situation as important to clarify concepts.

Common Features of the Presentations

The teacher, Ms Nakedi, exercised a lot of patience during presentations. Presenters showed no urgency to start their presentations and some were showing off. The teacher did not want to be drawn into issues of control. This meant that she did not force learners to keep quiet when they appeared to be disruptive through asking too many questions or asked their fellow presenters impolitely to use the English language. She preferred to distance herself and allow the presentations to flow with the presenters handling it their own way.

Ms Nakedi's input was mainly related to facilitating discussion by bringing in key questions at important points during the presentations. For instance, single science learners were asked after they had been introduced to the analogy of blindfolded people in a confined space, to explain '*what would happen…' (W2D3 Nakedi, pg 2)* concerning collision. Another question related to the presentation on energy. Learners were asked '*why is it that when you increase the temperature, the rate increases…'* (W2D3 Nakedi, pg 2). Such questions acted as prompts for learners to relate the observable with what was happening at micro level. Such interventions were made several times at various points during the discussion to help maintain focus on the subject matter involved and to direct learners' thinking. This appeared to enhance the quality of the discussions.

The teacher occasionally showed her disapproval of certain kinds of talk especially bad language or impoliteness to presenters. For instance, the teacher said '*…ask properly, ka maitseo, wa reng wa reng keeng?' (W3D2 Nakedi, pg 3).' The* teacher was rebuking the student who asked '*what are you saying'*, which the teacher considered to be impolite.

Challenges to Presentations

In the low achieving class, presentations were short, and not as comprehensive as those made by triple science learners. Though language was a communication barrier to both set of classes, single science learners battled more with understanding concepts like 'proportion' and 'concentration'. Keeping these learners focused was also a problem as they easily turned to sarcasm and mocking responses given by their peers while not making any constructive contributions. After the teacher had said to a learner *'…explain in terms of collision theory why an increase in number of particles will increase the rate of reaction…' (W3D2 Nakedi, pg 3*', the learners mocked the girl (Gakenalepe) whose name translated means, 'I don't have any (word)'. They laughed at her because she said she did not have any idea.

It is clear from above that Ms Nakedi's task was more complicated with the single science learners than with the triple science learners. She had to come up with many questions to try and engage the learners (as indicated above). Every time learners gave a response, she had to embellish what they said to bring more meaning. This was mainly done by bringing in a lot of examples, especially the use of analogies. All the

analogies used, seemed to be very relevant and easily shifted ideas learners possessed from surface features to deeper chemistry knowledge. Staying on task was also a big problem in this class, as learners easily lost focus.

Variation in Teaching Approaches

Though the lessons were dominated by learner-centred approaches, Ms Nakedi also employed other methods that engaged learners. Methods involving whole class discussion were used mainly when the teacher was introducing new topics, for instance the discussion of aluminium, zinc and copper metals with the triple science class. However, learners had been tasked with reading some material prior to that. A whole class discussion was also used when the teacher was reviewing tests. The teacher guided discussions using high-order questions for example, questions relating to significance of changing the quantity of carbon in producing steel. The excerpt below exemplifies the type of conversations occurring during a whole-class discussion with her triple science class:

T: which better property does steel have which is better than that of a (pure) metal?
S: Does not corrode
T: really, there is a difference between steel and stainless steel!
S: Used for car bodies…
T: if it does not rust why is it painted then?
S: Make it look beautiful
T: But it is painted mainly to avoid rusting…but the question was why it is used for car bodies? Alloys are hard, as iron is soft and bends easily, as if the car was used with Fe, which is soft…. As she tried to continue one boy said…
S: Otherwise it would get broken on the way'… Another boy insists the presenter talk about the percentages of metals found in steel alloy… (W1D3 Nakedi, pg 2)

Learners generally participated, talking freely during class discussion. The teacher was firmer during whole-class discussion, showing her displeasure when learners' talk deviated from what she wanted. She rebuked disruptive learners to force them to control themselves. Each time learners gave responses the teacher would build on those responses, expanding and relating them to other concepts. An example is a student who attempted to give the reason for converting metals to alloys, saying

S: To improve electrical resistance of a metal (There was laughter until the teacher said)
T: stop laughing… is it to improve or to reduce resistance? Why do you want to make something even more electrical resistant… because what this means is that it was a good electrical conductor, but you now want to make it a poor electrical substance… what were you trying to say? [She fails to support her view and the teacher now said,] let's leave it maybe she will come and tell me alone.

S: low melting point

The teacher expands on this and said, 'with low melting points things can be moulded into shapes. Take an example of a trumpet, one has to lower the melting point, mould it to that shape…' (W2D1 Nakedi, pg 3)

Further examples included reasons as to why certain alloys have improved physical properties such as strength, bending or stretching. She related this to microscopic arrangement of particles they learned previously drawing from arrangement of solid particles. She gave an expert opinion as she picked up all brief utterances and expanded them.

Test Reviews - Learners' Involvement during Test Reviews

These sessions when tests were handed back to learners were used as feedback, also to tackle problems encountered in tests as well as to extend opportunities for learners to engage. Handing back tests was also used to send a message about performance in class, The scripts were sorted according to marks obtained with those with lowest marks receiving theirs first. She believed that this motivated learners and at the same time made them dislike failing. Publishing results on notice boards seemed to have been done for the same reasons. The majority of learners (both triple and single science) generally performed badly in the tests. Their responses conveyed their sense of discomfort, concern and in some cases disillusionment. For instance one student said, "…*we have given up in chemistry' (W2D2 Nakedi, pg 2*). The teacher's reaction was always to console them, making them aware there were still many more chances to improve before the final examinations. Learners were made aware that these tests were very simple as long as they follow procedural steps to work out solutions

T: For question 2, for you to get the answer wrong it meant you got the formula wrong…
S: 1 mole of Ca…according to the equation…!!
T: That's how simple it was, what did you expect (W2D2 Nakedi, pg 1)

Test reviews also seemed directed at helping learners to learn algorithmic procedures for calculations by drill and practice. To ensure mastery of the procedural steps, learners were encouraged to participate extensively during test revision at the board. In Ms Nakedi's class many learners volunteered to go to the board to do calculations. Most test questions were based on the mole concept and separation techniques. Learners preferred to do all the calculations first without explaining the steps.

Calculations were viewed to be more important. Explaining the steps taken in doing a calculation was done after completing all the work. Language problems seemed to play a part in failure to explain at the same time as writing. What some learners said seemed to sum up their problems. When the teacher asked what steps she could take to improve their performance they responded:

> …When I read I don't understand….
> …Re rute ka Setswana… [Teach us in Setswana] (W2D2 Nakedi, pg 2)

Most learners seemed to face difficulties working on questions that demanded knowledge of experimentation as well as word problems in stoichiometry. For instance, they struggled to figure out how to prepare barium sulphate from two soluble salts. Lack of understanding regarding solubility rules seemed a problem. This led to most ignoring the precipitation reaction, preferring the shorter route of a reaction between the metal barium with sulphuric acid.

Summary of Ms Nakedi's Teaching

Many learners seemed to gain from searching for information, leading to communication skill development and better understanding of concepts. However, there appeared to be a difference in the extent the presentation method was successful between the two streams. The good aspects were evident in both streams and showed learners interacting with the teacher, their peers and with the material. But lack of focus and at times class control problems seemed to affect the single science class.

Although Ms Nakedi made extensive use of learner presentations, she used more than one teaching approach in her lessons to engage learners. Characteristics of her teaching are summarised below:

- There was good teacher/learner and learner/learner communication. Ms Nakedi allowed learners to interact with each other verbally during presentations. Learners were able to ask questions, comment at various points during presentation sessions.
- The role of the teacher was to be a facilitator in classroom activities. She intervened only to embellish learners' responses in order to clarify concepts and improve understanding.

- Learners were obviously very involved. Presentations sparked controversies and at times discussions becoming more emotional.
- There appeared to be some control problems as learners wasted time or took time to settle and start their presentations.
- Language was also a big problem in both classes which seemed to limit the kind of debate or interactions that could go on. Due to limited ability in engaging with chemistry issues, some learners quickly diverted the focus from themselves by mocking others or using sarcasm. Language problems seemed to be associated with problems in understanding.
- Where the teacher attempted to let the lessons flow with little interference, in same cases talk was easily derailed from the chemistry issues at hand.
- Learning gains were to be equal in all classes, for instance in some classes, learners were less focused and teacher had to talk more. Most of these challenges were more apparent in the single science learners who seemed to have more difficulty with understanding, with staying focused and generally appeared to have a poorer background in chemistry.
- Lack of exposure to practical work seemed to limit the extent to which learners contributed to the lessons. In instances where learners' presentations could have included an experiment, for example a demonstration of the effect of concentration and heat on reaction rates, learners did not include this in their lesson designs.
- The teacher used the same approaches for all the classes irrespective of the stream. During seminar presentations, single science learners seemed to gain less due to language problems and difficulty in staying focused.

The teacher often switched between languages, which appeared to encourage the learners to also use mixed languages.

9.3.2 Lessons Given by Mr Kopano

During the interview Mr Kopano indicated that he was aware that teaching was supposed to be more learner-directed than in the past. However, he was of the opinion that it is difficult to employ this method as it is too '*theoretical'* (Kopano interview, pg 3). He claimed to have knowledge of what such methods of teaching entails:

> Like if there is a topic I am supposed to do, what I could do is to say; this is how we are going to approach this topic. You are going to do this and that and that in class. They do the work, and I give them guidance like if you do this you are wrong, if you do this, you are right…, (Kopano interview, pg 6)

He had been in the field for less than a year, and naïve interpretations of the new curriculum can probably be linked to his lack of experience, because in his lessons he still took centre stage, talking more, marking assignments and writing long notes on board (see photos in figure 9.3 and 9.4). From table 6.2, it was evident that Mr Kopano's most favoured teaching approach can be described as the lecture method. Mr Kopano was not only lacking in teaching experience, he also revealed that he knew his pedagogical knowledge was also weak, not allowing him to deal with all his teaching demands. It was therefore interesting to see whether the deficiencies he mentioned affected what happened in his classrooms.

Types of Classroom Interaction

Mr Kopano's lessons were dominated by what can be called the lecture method accompanied by a lot of note writing (figure 6.3 below). In introducing concepts, he preferred to have a minimal role played by learners. He thought he was encouraging or prompting the learners to participate by asking rhetorical questions like '*do you understand', 'is it clear'* or he said to them *'if you don't understand, you can ask'* (W1D5 Kopano, pg 3)'. None of this stirred learners to participate in the lesson, even though it was clear they did not understand. It was evident during teaching that he also struggled with finding good ways of explaining new scientific words or concepts. For instance, new words like 'assumed masses, relative, convention' were casually explained. Responding to a student who had asked,

> S: Teacher… why is the atomic number always written at the bottom?
> T: Ke convention fela. (It's just a convention) (W1D5 Kopano, pg 3)

Since these learners generally had a weak English background it was easy to conclude that the student would not even understand what a convention was. Mr Kopano seemed to take learners' lack of understanding very lightly, taking it to mean that they were not serious. An excerpt from the field notes below showed learner responses as they were required to supply information on how the sodium atom was constructed. They were to use the formula:

Mass number = number of protons + number of neutrons

Mr Kopano wrote the formula on the board and learners were required to calculate one of the variables, given the other two. The learners struggled when with the task which the teacher thought was very simple. Dealing with the sodium atom the teacher asked:

T: how many protons are there?
S1: 2… (Some learners laugh at this answer)
S2: 11
T: Neutrons?
S: 11, 23 [responses are heard]
T: you will soon regret
S: 11 (W1D5 Kopano, pg 3)

The teacher expected learners to understand easily and if not to ask questions. But responses like those above from the learners showed that they faced greater difficulties than Mr Kopano could have imagined. One girl, frustrated, said aloud, '*Nna topic e e ya mpalela (*this topic is too difficult for me…)' (W1D5 Kopano, pg 3).

In Mr Kopano's lessons ideas were presented without opportunity for discussion. For instance, explaining subatomic particles,

> Scientists have been able to find that this small particle (atom) also contains some smaller particles inside and they called them protons, electrons and neutrons. They do have masses and that for the electron was found to be $1/1840^{th}$ that of a proton… (W2D3 Kopano, pg 1)

The teacher talked about the assumed masses and when asked if they understood, they all responded '*yes*'. Whenever learners did say they did not understand, the teacher did not offer any help, telling them it would be clearer as they read the notes. Occasionally during the lessons, learners would be so bored that they began to feel sleepy. If this happened, learners were asked to stand on their feet to keep awake (figures 9.1 and 9.2).

Figure 9.1: Learners copying notes

Figure 9.2: Learners feeling groggy and having to stand copying notes

All Mr Kopano's form 4 classes were covering the same topic 'atomic structure'. It was common to find learners bored due to lack of understanding or involvement. The teacher seemed to be very limited in the methods or representations he could use to engage learners. An example of this was during his explanation the contribution of the subatomic particles to the overall mass of the atom. *'... the mass of an atom depend much on the nucleus because the mass of an electron is insignificant….'* (W2D3 Kopano, pg 1). He read from their faces that they did not understand and instead of trying another strategy such as using another example or an analogy, Mr Kopano repeated the explanation in exactly the way he said it first. As indicated in the classroom observation notes,

> …The teacher goes over that again and explains that, this does not seem to make sense to the learners and each explanation was more or less just the replication of what was said first. (W2D3 Kopano, pg 1)

Mr Kopano was seriously constrained in this topic by his lack of experience and his lack of flexibility in pedagogical knowledge.

Variation of Teaching Methods

Mr Kopano occasionally organised activities that engaged learners both physically and mentally. Homework and class exercises were given to help learners get acquainted with the concepts after his lectures. Monitoring this seemed to be a problem as he committed a great deal of time to checking and marking learners' work. While he was doing checking, the rest of the learners who were left unattended made a noise which the teacher seemed to lack the authority to stop.

> T: I don't want to hear anyone talking
> Ss: Ehhhh (yes) (many voices responded)
> T: Whoever is talking has broken the rule gakere?
> Ss: Eeh rra (yes sir) (W1D3 Kopano, pg 2)

Mr Kopano's most constructive teaching seemed to occur when he was checking, marking or correcting individual work. The teacher himself attributed the lack of dialogue during teaching to learners' language barriers. During the interview he stated,

> …the form fours really are not that confident with English… using just English definitely at the end of the day you will find that you were only like communicating with one or two learners in a class. And when it's like that it doesn't benefit anyone it doesn't benefit a teacher, it doesn't benefit the learners … (Kopano Interview pg 7)

Mr Kopano mixed English and Setswana as he taught. He justified his approach because he thought it enhanced both participation and understanding. In reality, flexibility with language did not open up learners to participate more, as talk remained confined to individual benches as the teacher made his rounds attending to the class exercises he had set. Overall the dominant feature of his classes was of obedient learners in a class setting that entirely teacher-dependent.

Summary of Mr Kopano's Teaching

Mr Kopano was one of the youngest and inexperienced chemistry teachers in science at his school. Due to lack of teaching experience, he seemed to have difficulty in

structuring and managing lessons. The observations suggest that Mr Kopano's lessons were dominated by the following:

- There was poor teaching time management. Mr Kopano was observed marking homework for an entire double class session (~80 minutes). Learners whose work was marked or waiting for the teacher to come had nothing to do so were disruptive.
- Mr Kopano had poor class management and allowed learners to make a noise. According to him, his reason for not telling learners to keep quiet was that he wanted to encourage them to participate more in class.
- There was a great deal of note writing during lessons. This seemed to be given higher priority than the lesson development and teaching. Teaching of difficult concepts was usually rushed, as the teacher wanted to give more time to note writing. The rushing of concepts was probably due to the fact that Mr Kopano admitted that he was unsure of how to gauge the depth and breadth of content to be taught. As a result of covering a lot of content in a short time learners were generally overloaded with information, thus leading to problems with understanding.
- The lack of variation in teaching, in initiating questions, probing and encouraging learners' talk meant minimal engagement. Lack of stimulation led to learners feeling sleepy most of the time, even early in the morning.
- There was a lack of record keeping and preparedness for specific classes. The teacher was teaching the same topic to all the classes he was teaching, yet it was common for him to come to class not knowing which class he was going to teach, and how far he had gone with them. This created a loss of confidence from the learners as they felt he did not come to lessons well prepared.
- The teacher generally had a poor knowledge of his learners. He especially had poor abilities to put content into context and did not seem to know how to probe for prior knowledge. He spent little time on reflecting on the notes taken in class.

Weaknesses in the above areas was not surprising considering that Mr Kopano, had a weak background in teaching methodologies. A weak educational background in his training led to limited abilities in classroom pedagogical issues.

9.3.3 Lessons Given by Ms Bolaane

Ms Bolaane indicated during the interview that she had good knowledge concerning teaching and learning in the new curriculum, but acknowledged that in her case lack of serious thought given to preparing for classes was what had led to poor quality teaching. She admitted that, though she knew that teaching in the new system was supposed to engage learners more than in the past, she had not done that effectively. The problem, according to her, was that there was no incentive to force teachers to plan well and have constructive lessons. She said that as a learner during her teaching practice she had prepared her lessons well, but because this preparation was no longer monitored, her tendency was to do just enough to get by in her teaching. Ms Bolaane seemed to have limited pedagogical content knowledge.

Ms Bolaane's lessons were dominated by lecturing, accompanied with note writing like Mr Kopano's. The difference was that her lecturing mode was more interactive, involving probing questions and attempts to contextualise chemistry concepts. Learners did participate, asking questions and responding to questions posed. Ms Bolaane did not want her learners to talk too much, especially during her teaching or when not asked to. She preferred obedient reactions from all her learners in a more orderly manner. Lectures were complemented by giving class exercises, which she followed up by marking to confirm progress.

Figure 9.3: Ms Bolaane marking a student's class exercise

Nature of Interaction in a Triple Science Class

Content driven teaching was evident in Ms Bolaane's lessons. For instance, learners were rushed through a lecture on metallic bonding, naming of compounds and

derivation of formulae of compounds, finishing with equations and balancing equations. Ms Bolaane generally held her triple science class in high regard. She did not expect them to struggle to grasp concepts she introduced, hence she overloaded them. For her, if they failed to understand this would have been a sign that they did not deserve to take the triple science stream. Though at face value, learners appeared to have few problems with understanding as they worked out examples, it turned out during a quiz that writing equations were still problematic to most.

Variation of Teaching Methods

Ms Bolaane liked to introduce or develop chemistry concepts through telling what she called stories to help with understanding and also make lessons more interesting. She also strengthened her lecture method by use of a lot of familiar application examples and analogies. Learners seemed to like the stories and analogies as they expressed enjoyment.

When Ms Bolaane tried to place science concepts into understandable context, she communicated using words that were in learners' vocabularies and used ideas related to their past experiences. For instance when introducing formulae, equations and reasons for having shortened names, she said

> …there are many ways of calling each other. Like if one has a long name like… 'Matshidiso' to 'Tshidi' in chemistry scientists also prefer to cut names to shorter version, like the name calcium carbonate, nitrogen dioxide, carbon monoxide …like N_2O_5, N_2O_3, and Fe_3O_4 (W1D4 Bolaane, pg 2)

The teacher did not explain the link between the example and the target concepts. She gave a story of the death of a couple in Lesedi Village during her secondary school days. She said they:

> … died due to carbon monoxide poisoning…people in the village where talking of how bewitched the pair was …(W2D5 Bolaane, pg 3)

She said she knew that it was nothing to do with witchcraft. After the story she then talked of how the word redox originated from the concept of loss or gain of oxygen. Teaching the same class the concept of spectator ions in '*ionic equations'*, she used another anology that seemed to bring understanding to learners. She said that:

> …when you watch the Zebras (Botswana national football team) playing, you are just a spectator, even when you are happy saying 'the Zebras, the Zebras, (are winning)…you are not a player, but just a spectator…even here we have spectators… (W3D2 Bolaane, pg 4)

The examples were questionable in terms of their suitability for the concepts they were meant to explain, but there was no doubt that learners liked these. Ms Bolaane spiced up her examples with jokes linking the idea of spectator ions with their roles when watching the local boxer, and even their village teams. These examples which seemed to be trivial nonetheless had some general meaning associated with cultural experiences and familiar stories or situations shared by all learners. Assisted in this way by the stories and their meaning, learners constructed new meanings. Hence these analogies served as powerful resources that aided learners in interpretation of new situations. The teacher's use of context related stories became a strong resource which she used to guide her teaching.

Nature of Interactions in a Triple Science Class - Quiz Task

Learners' were generally minimally involved in class as the teacher preferred the chalk-and-talk method. She preferred to do all the talking and controlled what learners said. Excessive talking was stifled as the teacher would threaten learners using a harsh voice:

> …not like people who speaks when I am speaking disturbing others…' or '...I will kill you and then go and report to the church … (W1D3 Bolaane, pg 2)

Though she sounded sarcastic at times, learners seemed puzzled by these extreme threats or jokes. Her threats served their purpose though, because she was able to exert maximum control during teaching.

The teacher viewed giving quizzes, assignments and tests, which she did very regularly, as getting learners involved. She believed that constantly engaging learners throughout the program would help dispel complacency, so that learners would remain focused for the duration of their study. As already stated, from her perspective, engagement did not necessarily mean that learners participated in discussions, or thought provoking talk, but meant that they were keeping themselves occupied with written tasks.

The quiz, which later turned out to be a class exercise, turned out to be activity where learners were most involved. This quiz, which was to be graded, was designed to summarise what had been learned in the topic on formulae and equations. Learners were to derive formulae from word equations, balance the equations and include states. The majority of learners struggled, showing they did not understand. Some learners were able to derive symbolic representations of reactions, but could not balance the equations. The teacher eventually allowed learners to consult with each other when she realised the task was not fruitful. Some learners started to work in small groups to solve the tasks together, but even when they were working together, learners still faced problems as their interest remained in:

- Looking for the right formula to balance equations
- Copying from others (individuals or groups) or
- Hurrying to get correct answers without understanding the work behind balancing

Learners' benefit from these interactions seemed limited. Since the basis of the task was for testing purposes, most learners did not see that talking to each other was an opportunity to build process and thinking skills and understanding. Most learners were only interested in the correct answers. If the teacher had carefully thought about what the purpose of the task was, she could have changed the focus from getting correct answers to encouraging learners to reason at a higher level.

The way she changed her plans in an uncoordinated manner seems to suggest that Ms Bolaane came to lessons not quite sure of what her exact plan of action was. This statement is based on the fact that some days she would talk about not being prepared to teach and so preferring to give a quiz or revise test papers. On these days, she would attempt to discourage the attendance of the researcher as she felt it would not suit the research study saying '*there is no teaching' (*W1D3 Bolaane, pg 1) to be done. This seems to confirm her what she said during the interview about no longer giving serious thought to planning for lessons, although she had done so during her training. Some evidence of lack of planning can be found in:

- The way she changed the quiz task to a discussion. This was not planned and the learners' lack of understanding was unanticipated.

- In another two separate instances Ms Bolaane was distributing test papers which the learners had written. This was done without any urgency and consequently consumed a lot of time. A great deal of time was also spent on commenting on the marks achieved, before the teacher started introducing a topic for the day e.g. teaching '*Ionic Equations'* (W3D2 Bolaane, pg 4). Time spent on the topic was also cut short as the teacher later engaged learners in some 'moral education' on how they should conduct themselves during the school break.
- In another class the teacher spent a lot of lesson time rebuking learners for failing a test before starting to review the test questions. A long assignment was later given as the teacher claimed she wanted to keep them focused and occupied during recess to stay away from mischievous activities like visiting bars.

The issues raised above seemed to suggest that Ms Bolaane went to her lessons under-prepared and therefore attempted to fill the available time with odd activities.

Summary of Ms Bolaane's Teaching

Ms Bolaane seemed to be limited in her approaches to teaching, with little evidence of engaging learners during teaching. According to her this could be attributed to failure to prepare her lessons carefully. She stifled learner participation by taking the centre stage during teaching. Despite this, Ms Bolaane used real life examples to help strengthen concepts by use of analogies and application of science representations. Use of analogies and contextualisation were at times not properly linked with the concepts. So, although they kept the learners interested they could have been more effective if deliberately linked with the concepts they were intended to illustrate. Engagement in her classes was mainly in the form of using homework, quizzes and classroom activities which she marked during the lesson (see fig. 9.3). These activities were also done individually by learners. She also attempted to make her lessons livelier by telling stories related to the chemistry issues taught. Learners seemed to enjoy her teaching.

Another clearly stated aim of the BGCSE curriculum was to increase the exposure learners had to hands-on activities. How the teachers dealt with this requirement will now be shown.

9.4 Hands on Activities - Practical Work at Lesedi SSS

The teachers were definitely aware of the importance of laboratory activities in the BGCSE because during the interviews, the three teachers talked highly about experimentation. They viewed the BGCSE curriculum as demanding constant use of practical work for all the science streams. Teachers generally felt that teaching requires learner-centred approaches. Despite the high value they claimed to place on practical work, the teachers generally felt that as a teaching method it was not practical to use.

Practical work observed in Lesedi SSS will now be described.

9.4.1 Experiments Observed

Lesedi SSS teachers were not observed performing any experiments during lessons. The only practical activity observed was the standard monthly practical test organised by the science department for all form five triple science learners in the school. Two of Ms Nakedi's triple science classes participated. Altogether, four classes in the school performed the practical work.

Figure 9.4: Lesedi SSS learners performing a practical test

Each learner had his/her own set-up of apparatus and reagents to use. During the session it was observed that the majority of learners seemed to feel uneasy while conducting the experiments. One of the experiments involved a titration and a test for gases, lasting one and a half hours.

Field notes showed that when the marks obtained in the practical test were discussed, the performance in the test had been unsatisfactory. Learners' complaints during revision revealed that practical activities were not common in this class. Failure to carry out various components of the test such as titrations and test for ions indicated lack of practice. Learners also pointed out that the infrequency of experiments meant that they could not perfect the manipulative skills needed in titration and test for ions.

The practical examination was structured to follow the BGCSE examination model, involving both qualitative and quantitative tasks. Learners performed titrations followed by calculations and several tests to identify ions from a given unknown sample. During the practical review, the teacher highlighted misconceptions and all the problems she had picked up during invigilation and marking. The teacher's reaction to the practical test was that there had been too many mistakes related to process skills, but fewer mistakes in calculations. The quotation from the field notes indicates some of the problems that affected the learners:

> When told by the teacher about removing the funnel or tips of having to start afresh when some solutions have dripped in or out of the burette, they told the teacher it takes all the time, (W3D3 Nakedi, pg 2)

Another problem highlighted from the discussion was:

> …What the 0 mark and 50 mark on burette really mean…learners argued that… 'you cannot say zero when the burette is full…' (W3D3 Nakedi, pg 2)

The teacher did not seem to convince them with her explanations, till she demonstrated the whole practical task.

Table 9.3: A summary of problems encountered by learners during a practical

	Reading	**Recording /tabulation**	**Manipulative skills**
Mistakes observed	- Inability to follow instructions (given procedures) - Meniscus reading - Using a burette: learners did not know how to read it	- Tabulating and handling data, such as calculating volume used from a burette and even recording data	- Failing to obtain accurate data especially for titrations (best titres) - Failing to discard or start afresh when reading or something goes wrong during the titration - Failing to remove a funnel

The above inventory of mistakes cited by the teacher, confirmed the learners' concerns that they had never been exposed to practical work and so their ability to handle such tests was poor. Despite the teachers' knowledge that learners struggled

with issues related with practical work, they did not allow learners any more opportunities to do practical work.

9.4.2 Purpose of Practical Work

In addition to preparing learners for the final BGCSE practical examinations, practical sessions seemed to have been designed to help learners develop practical manipulative skills. For instance, during the revision a number of issues were raised. Ms Nakedi had wanted learners to master certain skills such as taking readings, recording, tabulation and other manipulative skills needed to perform both qualitative and quantitative experiments. Learners felt that learning these skills during an examination was not the right kind of setup to practice those skills and that their weaknesses in procedural skills had been their downfall in the previous practical examination.

During the test review, learners challenged Ms Nakedi to organise more laboratory sessions during teaching times. They felt that lack of exposure had made them disregard important steps like repeating titrations. Even the reading required to follow instructions would have been better with more practice. Learners thought that titration values would always be the same. Some learners also saw no point in repeating a titration after having done a rough titration. Other mistakes included not knowing how to use a burette properly, for example not understanding that a burette reading should be recorded as 0.00 ml when it is full and not 50.00 ml.

9.4.3 Practical Work - As Diagnostic Test

Ms Nakedi appeared to be well prepared for this test review. She brought an inventory of problems learners encountered performing the practical, which was very helpful. This resulted in an engagement with learners on a range of issues related to the practical activity. For instance, Ms Nakedi directed her intervention to building procedural knowledge, as most learners displayed weak background skills. The teacher brought all the apparatus and chemicals used in the practical to perform a demonstration as they discussed. During the discussion she broke down the procedure, by reading and indicating what needed to have been done. The teacher

attempted to simplify the investigative practical procedure so learners could follow easily as shown in figure 9.5 below.

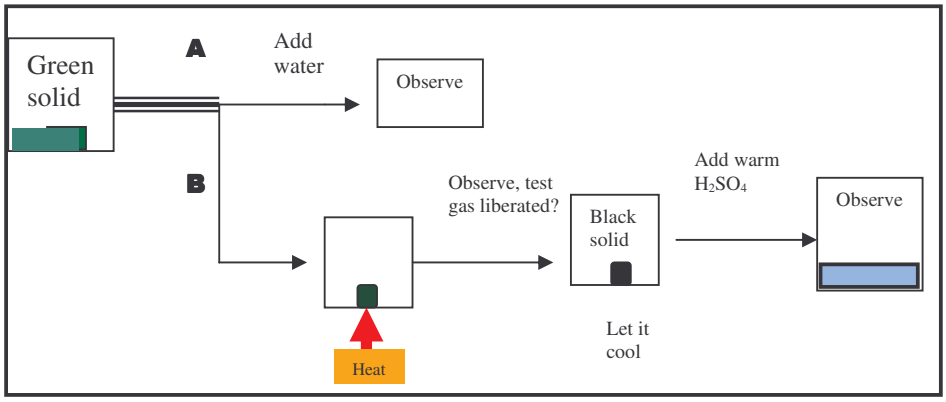


Figure 9.5: Investigative/qualitative Practical test

Inability to follow instructions meant some learners had heated the whole sample right at the beginning (procedure B), thus ruining the whole investigation. Some learners where observed using up the whole sample for procedure 'A'. Taking learners through the stages and processes involved seemed to help clear up the poor reading skills.

9.5 Summary: The Teachers and their Teaching at Lesedi SSS

A summary of the teachers' perception of the curriculum changes and what teaching and learning meant to them is given in table 9.4.

Table 9.4: Lesedi SSS teachers' perception about curriculum changes

Perception	Content changes	Assessment changes	Teaching and learning changes	Readiness to implement
Ms Nakedi	- Contextualisation and application incorporated - New topics/ objectives	Addition of paper 4: practical oriented	Learner-centred: Quizzes, exercises, inquiries, presentations, experiments	Ready
Mr Kopano	Removal of topics	Grading system-made easy	Learner-centred - Experimentation	Not ready
Ms Bolaane	Curriculum remained the same	Grades/grading system different and Complex	Learner-centred - Experimentation - Tests/ quizzes, homework	Ready

Table 9.4 shows that the most obvious changes in curriculum to teachers included the changes of syllabus content, assessment procedures and teaching and learning approaches. All teachers viewed the introduction of experiments and demonstrations as the most obvious intention of the BGCSE curriculum and two of the three teachers

felt they were ready to implement the prescribed changes. Not shown on the table is the fact that teachers at Lesedi SSS generally saw changes having occurred at policy level, but not at implementation or practice level. It was also argued that in practice, the required level of learner involvement was not possible due to other pressures such as the need to complete the syllabus.

Teachers and Their Practice

Table 9.5 below summarises what was actually seen to be happening in the classrooms of the three teachers observed.

Table 9.5: Lesedi SSS teachers' Teaching Practice

Practice	Contextualisation and application	Teaching approach	Classroom practical-work	Treatment of Streams	Learner Involvement/participation/PCK
Ms Nakedi	Highly contextualised - analogies; application of sc.	Learner-centred: Learner presentations	Not observed	Same treatment	Hands-on or minds-on - Assigned reading task - Discussions/ argumentations: during presentations - well developed PCK
Mr Kopano	Non existent	Teacher – domination Chalk-talk	Not observed	Same treatment	- Minimal involvement in hands/minds-on activities - Some assignments given - moderately developed PCK
Ms Bolaane	Highly contextualised - Use of stories; real life examples	Teacher-Centred- with a degree of interaction	Not observed	Differed - Teacher mocked single sc. learners	Hands & minds-on; problem solving questions (homework); Quiz -underdeveloped PCK

The table shows that Ms Nakedi was the only teacher who tried to involve learners in classroom discourse. For this teacher, it could be said there was consistency between what the BGCSE demands and what was happening in her practice. And it has already been mentioned that learners benefited from the search for information and lesson talks.

The table also shows that there was no practical work or demonstrations observed during lessons. Teachers excused this saying that practical activities can only run well in a situation where teachers have lower work loads, qualified laboratory assistant and a laboratory reserved just for practical work. However it was observed that the form five triple science learners had to do experiments in an examination setting without prior practice. Only when the practical tests were complete did the teacher take any trouble to demonstrate the procedures and explain the approaches and reasoning.

9.6 Discussions of Findings for Lesedi SSS

Following the scrutinisation of the three teachers at Lesedi SSS and their classroom interactions and teaching patterns the information above makes it possible to identify the ZFI for the school. Each teacher's current level of operation on the dimensions of the profile of implementation will be summarized based on the information above. This will then help identify the ZFI for each teacher and eventually the school. The three dimensions discussed in this chapter included classroom interactions, science practical work and contextualization. Classroom interactions in this study included teaching patterns and activities as well as assessment components attached during teaching.

DISCUSSING LESEDI SSS OPERATIONAL LEVELS

First it was necessary to discern the current practice of all the teachers in a summary form. The summary (table 9.6) indicates patterns in the three dimensions classroom interactions, practical work and contextualisation.

Table 9.6: The Operational Indicators of Lesedi SSS Teachers

Name	Classroom Interactions	Practical Work	Contextualisation
Ms Nakedi	Chalk and talk minimal Detailed notes provided Use of additional sources of information for presentation notes Homework given regularly Monthly tests given *Minds-on activities and Learners engagement in: class discussions; learner investigations and learner presentations*	No practical work or demonstrations observed during lessons *Practical examination given* *Qualitative/ quantitative aspects covered* *Highly engaging discussions reviewing practical work*	Teacher use examples and application from everyday life *Inquiries and presentations on concepts linked to application of science (contexts)*
Ms Bolaane	Chalk and talk minimal Disjointed lesson planning Detailed notes provided Variety of poorly coordinated activities *Meaningful and deep engaging questions*	No practical work or demonstrations observed	Teacher use examples and application from everyday life and story telling regularly
Mr Kopano	Chalk-and-talk dominated lessons Detailed notes provided Low order questions common *Minimal hands-on and minds-on engagement*	No practical work or demonstrations observed	No application of science or link to real life (to illustrate difficult concepts)

From the current practice it is possible to predict operational levels for each teacher and eventually the ZFI for the school. A full description of the conversion of the summary indicators (table 9.6) to operational levels was discussed in detail in chapter 6. The procedure was followed in this chapter and the results were entered in table 9.7

Table 9.7: Operational levels of teachers at Lesedi SSS

Name	Operational Levels		
	CI	PW	Contextualisation
Ms Nakedi	3	2	2.5
Ms Bolaane	2.5	0	2.5
Mr Kopano	1	0	1
Average	2	1	2.5

The results on the table 9.7 above were used to come up with the figure 9.6 below. This way, the operational levels were useful also in predicting the ZFI for the school, shown by the grey colour.

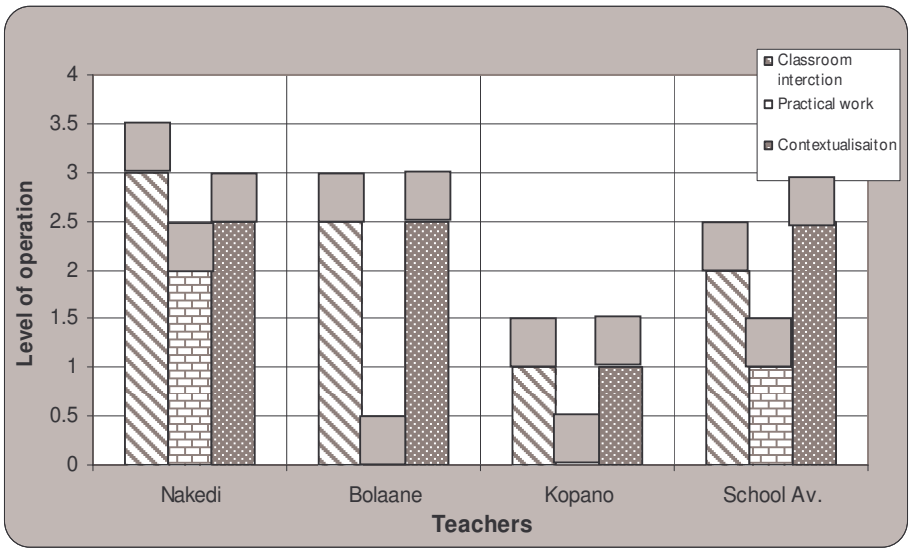


Figure 9.6: Lesedi SSS' levels of operation

According to the figure above, the more experienced teachers fared better than the less experienced teacher Mr Kopano. For instance Ms Nakedi, as already documented blended learners' oral presentations which involved searching for information on given topics and later teaching peers. Class discussions that accompanied presentations also appeared meaningful and effective. Such regular classroom exercises appeared to be a very successful strategy as learners especially the triple science learner researched well before the lessons. The weaknesses on the methods requiring classroom discourse was lack of effectiveness when the single science learners were involved. The learners superficially prepared for lessons which consequently led to superficial presentations and contributions.

Ms Nakedi did not encourage learners to include practical work activities during presentations though some of the topics would have been more understandable

accompanied by experiments. For instance the presentation on the factors affecting reaction rates could have been complemented by experiments. Ms Nakedi ensured learners understood these concepts by allowing flexibility in communications as learners mixed language. When making explanations where learners faced language problems, she translated or at times inserting Setswana words or phrases into explanations which seemed to result in understanding. This also encouraged participation by majority of learners. Other forms of representations such as use of analogies, application of science examples ensured learners' understanding was improved.

Ms Bolaane also strengthened her teaching through use of analogies and representations from real life examples. Though some examples appeared not so relevant or well linked to target concepts, they had great potential. Teaching approaches were mainly teacher-centred. Class exercises, home work and quizzes were given in class to help engage learners. Such activities seemed mismanaged and it appeared that this could be the area where Ms Bolaane could be helped to improve.

Practical work did not seem a favoured approach in this school and according to her not devoting more time to prepare well for lessons was the real cause of the problem. In terms of teaching interactions, it could be said that she operated between level 2 and 3. She engaged learners with questions, exercises, quizzes which encouraged in-depth thinking. The level 3 did not appear stable and well developed because though she was observed encouraging learners to construct knowledge especially with the triple science and single science classes, she taught, she appeared at some point failing to direct the group activity well for learners to get the feeling of balancing of equations without having to copy correct answers form peers. Ms Bolaane also restricted learners' communication during lessons.

Mr Kopano appeared to operate between level 1 and 2. In terms of content he came to class well prepared. Long and detailed notes were always ready in his notebook which was always provided to learners several times during the lesson to complement his talk. He checked notes, gave learners home-work and class exercises that he checked and marked during the lesson. The major problem was failing to engage other learners in any meaningful activities when he was checking or marking homework or class

exercises. Learners whose work had been marked chatted and some slept as they were not engaged or challenged.

All this pointed to an inexperienced teacher with little PCK. He found it difficult to know how to engage learners and manage the classroom. Failure to engage or access learners prior knowledge was also problematic, as was the weakness in using analogies and other forms of representation such as real life examples during teaching. Mr Kopano complemented his weakness by inviting learners for extra help, so he could offer individualised help after school. He was not observed carrying out any practical work, therefore it was not clear what his level of operation would have been in this area. But during the interview he said he preferred demonstrations which showed he may not be operating above 2.

All the information above makes it possible to identify the ZFI for the school. The average of levels of operation of the teachers had been used to come up with a bar graph representative of the school (figure 9.6). From the figure, it could be deduced that teachers generally operated at a low level, at levels 2, 1 and 2.5 in terms of classroom interactions, practical work, and contextualisation of concepts when teaching. The results show several indications of whether teaching and learning can be considered as learner-centred in this school. From the level several deductions can be made concerning intervention measures that can help raise current practice.

Classroom interaction seemed to be directly related to the teaching experience of the three chemistry teachers. The more experienced the teacher, the more versatile the teacher was, thus, varying teaching approaches, engaging the learners more and even embracing constructivist approaches to teaching and learning more. In this school, limited ability to guide lessons well was common with the less experienced teachers. It was worst with Mr Kopano who with managing his lessons, failing to get learners to engage. Marking and note writing occupied most of his time. While he was marking, he left many learners unengaged and therefore off focus. Note writing was given more priority than lesson development. Mr Kopano could not contextualise content or use analogies or application examples during teaching. Unlike his more experienced colleagues, when learners did not understand he preferred to repeat explanation rather

than changing representations. This seemed to show that he was limited in terms of tools for teaching and unpacking content for students' consumption.

All teachers viewed language as a big constraint in teaching and learning. During lessons this manifested in many ways such as students mixing languages, teacher mixing Setswana and English. Some learners could not participate in class discussions well due to language barriers. The teachers encouraged code switching as a way to encourage learners to participate. Code switching was said to assist learners with understanding both the English language and the chemistry ideas.

Varied pedagogical competences could also be attributed to the experience of the teachers. The more experienced teachers seemed more comfortable with handling their classes well, helping students more with other forms of representations. Variety of teaching methods seemed to increase with experience of teachers. Teachers grew in confidence to handle and manage the classroom activities like exercises, debates, discussions and note writing. Depth of discussions also improved. The less experienced teacher preferred to attend to students' assignments individually and their difficulties from their tables ignoring the rest of the class. Content knowledge appeared strong for all the teachers, though the extent to which the three unpacked it for students differed significantly.

Strategies Needed For the School

Variations in terms of level of operations between teachers, as well as low levels of operation in terms of classroom activities, and practical work seem to point to professional development needs in this school. It was clear that though the ZFI for the school was not representative of all teachers, there was variation and gaps in each dimension for each teacher. In terms of classroom interaction dimension, only Ms Nakedi could be said to have engaged and challenged learners. Other teachers faired low in challenging learners and giving them opportunities to participate in classroom discourse. Ms Nakedi's method appeared to lack flexibility. Though learners could have been allowed to plan more hands-on activities, this was not done. Mr Kopano's lessons were mainly teacher dominated as he failed to balance his role and that of learners, manage time and control class well. Practical work was minimally viewed as

a feasible approach by all the teachers. This shows that having identified the current practice, and the ZFI for the school, it becomes possible to see where the school's strengths and weakness are to help it move forward.

The most appropriate interventions would target the Ms Bolaane and Mr Kopano to reach most of the activities Ms Nakedi did well with her learners. Ms Nakedi would need to improve her presentations to make them more flexible in having more activities planned by learners.

Chapter Conclusion

Lesedi SSS's practices have been explored and documented. The teachers' current practices were studied to help identify patterns in classroom interactions, nature of practical work carried out and inclusion of contextualisation in teaching chemistry. Operational level indicators helped to justify the identified ZFI. One of the intentions of identifying the gap is to help increase capacity to utilise the resources and thus expand the operational levels. Movement to the next level means one has to measure levels in order to help direct practice. Teacher-learner interactions varied greatly when comparing the three teachers:

- The most experienced teacher had better understanding of the BGCSE methodologies, and spent more time in the learner-teacher discussions whilst the least experienced spent more time on more teacher-dominated approaches.
- The more experienced teacher exposed learners to presentations were learners led the lesson proceedings
- Practical work was rarely used. In this regard it can be concluded that teachers did not seem to value it because they preferred other methods

CHAPTER 10 DISCUSSION AND CONCLUSIONS

Introduction

This chapter synthesises the findings from previous chapters as well as discussing the implications of the study for Rogan and Grayson's (2003) framework. An overview of the study introduces the chapter.

10. 1 Overview of the Study

The central purpose of this study was to find factors in school design and organisation that best promoted new curriculum implementation of chemistry at the senior secondary level in Botswana. School and classroom observations were conducted in four schools, and a total of 11 chemistry teachers of varying teaching experience participated. Teacher interviews formed part of the data collection processes to find their perspectives on the new curriculum and their own practices. The interviews also examined the ways in which teachers articulated the purpose and relevance of the new curriculum. This articulation was meant to shed light on the teachers' understanding of the structure of the new curriculum, on chemistry as a subject, on their awareness of changes and debates that occur in teaching and in the contexts in which they were immersed.

Lesson observations captured data on classroom conditions, activities, the content of the lessons, and level of learner participation and interactions. Rogan and Grayson's (2003) theory was used at various phases of the study to guide data collection, analysis and interpretations. The theory was also used to frame the findings. For instance, the findings used sub-constructs from the profile of implementation and the profile of capacity to support innovation.

To look into actions inside the classroom, the sub-themes classroom interactions, practical work and contextualisation was used to describe curriculum implementation conditions and activities. In all the schools, the levels of operation in terms of what was happening in the classroom were found to be at modest levels. This showed that implementation of the new curriculum was still lagging behind in terms of the BGCSE requirements set at higher levels in terms of Rogan and Grayson's scale.

Though there were moments when a few teachers in some schools reached a higher level, it was achieved only with elite science groups. The most common practices were dominated by lower operational levels, with a few activities and interactions operating higher. These levels point towards an inclination to teacher dominance and not many hands-on and minds-on activities.

The operational levels were also used in terms of capacity to support innovation to gauge readiness of schools to implement the curriculum. For instance, in terms of physical resources, it was found that all schools operated at a high level showing excellent infrastructural support in this regard. Other contributors were teachers and ecology and management systems factors which fared poorly as compared to the physical resources, but seemed to have had a large influence on curriculum implementation. This was so because of the macro and micro nature of departmental setups. The link between the physical distribution of teachers and its impact on teaching and learning and teachers' work in general has been discussed and justified. Functional departments were linked to the concept of community of practice and identities found in various schools. The nature of communities in the schools seemed to contribute to the morale and commitment to work.

The idea of a ZFI (Rogan & Grayson, 2003), was used along with all the sub-constructs to identify differences found in the schools, especially its relation to the nature of interventions required by each school for growth. It became clear from the discussion that identifying the operational level of a particular school was a powerful strategy to devise intervention for a specific school.

Following the above overview, the outlined issues including the implications to the methodologies will be discussed further.

10.2 Discussion of Findings

Findings can be broadly categorised as methodological findings and those relating to Rogan and Grayson's constructs. First, methodological findings will be discussed.

10.2.1 Methodological Findings

Due to the extensive use of Rogan and Grayson's (2003) theory in this study, it is important to reflect on the implications of findings on the framework put forward by Rogan and Grayson. Several aspects of the framework were used in this study. This therefore necessitates a discussion focusing on

- The applicability of the Rogan and Grayson theory
- The impact of the lack of grain-size of the operational levels
- The ZFI concept and
- Implications of the study sample composition on the theory and findings

10.2.2 Applicability of the Rogan and Grayson's (2003) Framework

The framework discussed by Rogan and Grayson (2003) was found very useful at various phases of the study. What was particularly useful was, for instance the sub-constructs that were used during data collection and analysis. The fact that levels of operations for the teachers and schools could be identified, was useful during interpretation. This framework has been used in several other studies. For instance, the framework has been used in determining the level of operation in terms of capacity, support and practice factors by Rogan and Aldous (2005), Rogan (2007) and Hattingh, Aldous and Rogan (2007). According to these studies, the theory was found to be useful for identifying the levels of operation and accurately portraying the ZFI for the schools. The research study discussed here attempted to use this framework in the same manner. However, in the studies mentioned, there was a need identified to describe more indicators for levels (Rogan & Aldous, 2005; Rogan, 2007; Hattingh et al., 2007). This seemed to suggest that there was recognition that the model was incomplete. A review by Lelliott, Mwakapenda, Doidge, du Plessis, Mholo, Msimanga, Mundalamo, Nakedi, and Bowie (In Press) during a survey of South African literature also used the framework as an evaluation tool. They were critical of the theory on the grounds of the limitations posed by the framework due to its lack of grain-size in the operational levels. This seemed to suggest that there were more levels needed, or alternatively refinement of the operational levels (Lelliott et al., In Press).

10.2.3 The Operational Levels

This study recognised the limitations posed by lack of clarity in accurately identifying indicators matching operational levels. The model (Rogan & Grayson, 2003) does not make allowance for intermediate values e.g. levels 2.5 or 3.5, which seemed appropriate in this study. Using physical resources as an example, it was found that resources in school were above those attributed to level 3, but not yet at level 4 (Rogan & Grayson, 2003). Hence, it was represented as 3.5 in this study, for the reasons that follow.

According to Rogan and Grayson's scale, a school operating at level 3 should have one science laboratory, but in Botswana senior schools studied, all had at least 3 chemistry specific laboratories which made the operational level higher than level 3 which suggest the higher level 4. However there were many other facets of level 4 that were deficient such as curriculum materials, teaching aids such as posters and the state of the grounds. Level 3.5 is between levels 3 and 4 as shown below.

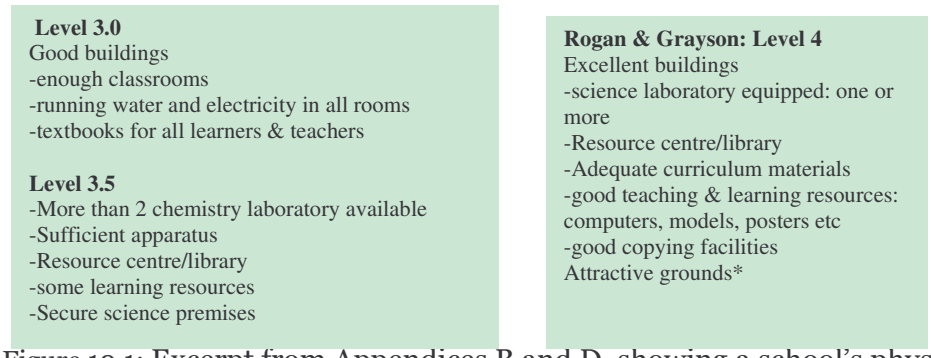


Figure 10.1: Excerpt from Appendices B and D, showing a school's physical resources

The new categories at level 3.5 seemed more suited to Botswana senior secondary schools, because though the schools appeared at face value to operate at the same levels, the fine-tuning appeared to help in isolating the differences found in the schools. A complete template showing all the new indicators and their categories was given in Appendices B and D.

10.2.4 Determination of the Operational Levels and the ZFI

Before the findings are detailed, the procedure followed to determine the operational levels and the ZFI will be described briefly here. This applies to both the capacity to innovate and curriculum implementation factors. This description is important because the operational levels and the ZFI concept formed an integral component for discussing the findings.

A description of how the levels of operation were determined in this study has been given above as well as in chapter 6. Indicators concerning capacity factors or teachers' practice were identified and later compared with template indicators adapted from Rogan and Grayson's scale. This comparison led to finding the actual operational level for a particular teacher. Since the interest was in the school, the operational levels of the three teachers in a school were averaged in order to come up with one value which could be viewed as representative of the school.

Calculating the School's Operational Level – Relevance

In calculating the operational levels, the mean, the median and the mode were all considered. It was apparent that the measure which was most useful in describing the data would be taken. The mode and median which considers the number that occurred most frequently and the number that is in the middle of the set, appeared unconvincing to use due the smallness of the sample. The mean, which measures the average value for the set of data, was used. In retrospect, the operational level could appear lower due to the ordinal nature of the data. The table below shows an example from two schools and how the values for the three compare.

Table 10.1: Teachers' Operational Levels at two schools showing mean, mode and median values

Names	CI	PW	Contextualisation
Mr Kgabo	2.5	2.5	2
Ms Malane	2.5	2.5	2
Mr Pula	2	2.5	2
Average	***2.5***	***2.5***	***2***
Mode	**2.5**	**2.5**	**2**
Median	**2.5**	**2.5**	**2**

Name	CI	PW	Contextualisation
Mr Mpho	3	3	3
Mr Bose	3	3	3
Mr Sunny	2	1	2
Average	***2.5***	***2.5***	***2.5***
Mode	***3***	***3***	***3***
Median	***3***	***3***	***3***

A look at the table 10.1 above shows that using the mode or median would have produced higher result. Hence, the use of the average value despite the ordinal nature of data.

Justification for Using ZFI in Steps of 0.5

The ZFI became the immediate region above the operational level, because the principle is about having the next step which is not too high above from the current situation. The ZFI was represented in the diagrams as 0.5 units ahead of current operational level of practice. In practice, the size of the ZFI depends on capacity factors. The better the capacity, the greater the amount of innovation that can be contemplated. This implies that it may be in wider steps than the one suggested. This means that in practice the ZFI is not always a neat 0.5 units in width. It has been reflected in the discussions made concerning the ZFI findings that the extent of the ZFI should not be determined from outside, but by those responsible for implementing the innovation. As Hopkins and MacGilchrist (1998) observed, '*those who are responsible for implementation should always have the right to say yes to some of the proposed innovations and no or not yet to others*'. Hence, a 0.5 unit in this regard was only used generally as the minimum amount of intervention range that may be applicable to any school.

10.2.5 Implications of the Study Research Sample on the Theory

It is clear that the average values of teacher operations ascribed to a school are influenced by the teacher sample and that this limits the generalisation of the levels.

At Domboshaba, Maru and Lesedi schools, there was a mix of teaching experience (table 6.1). At Tagala SSS, only the least experienced teachers participated in the study and yet their levels of operation were not the worst. Due to a generally young teaching force in Botswana, it became important to define teaching experience. The most experienced teachers were defined for the Botswana situation as those with 5 years or more of teaching experience. Moderately experienced were those who had been in the teaching field for at least 2 years whilst the least experienced teachers were those with less than 2 years in the field. Teaching experience was viewed as influential in the profile of implementation as well as the sub-construct teacher factors. For instance, teaching practice inside classrooms is greatly impacted by the teachers' SMK and PCK which are linked to teaching experience. The low teaching experience of the entire sample of Tagala teachers consequently had an adverse effect on the composite operational levels for school. This has implications too for making

generalisations about Tagala SSS and the Botswana secondary schools in general due to the non-representative sample.

The findings in terms of the selected constructs and sub-constructs will now be discussed.

10.3 Findings in Terms Of Rogan and Grayson's Constructs

In the discussion of the major findings, only two constructs, capacity to support innovation and profile of implementation will be used to categorise the discussion. Under capacity to innovate, three sub-constructs physical resources, teacher factors and ecology and management systems will be used. The other sub-construct, learner factors as indicated earlier, was left out. Though learners featured greatly on the teachers' perceptions about teaching the BGCSE curriculum, there was not much of data directly from learners used. Data about learners only came from teachers and was considered not adequate to give representative indicators for operational levels. Under the profile of implementation, the sub-constructs classroom interaction, practical work and contextualisation will be used as categories to enhance the discussion. At the end of each section, the ZFI will be identified to suggest intervention strategies suitable for the operational levels found. The format of the discussion is outlined below.

Outline of Discussion in Terms of Rogan and Grayson's Constructs

The findings for the four schools will be done under the following headings:

- Capacity to support innovation across schools
- Profile of implementation across schools
- Schools' capacity against their practices
- Nature of teacher distribution in the science departments
- Impact of teacher distribution on functionality of science departments
- Conclusions and implications of study for policy and schools; practice and research

10.3.1 Capacity to Support Innovation across Schools

Though all factors were analysed, only those that appeared prominently in the study were discussed. Only three capacity factors (physical resources, teachers and the school ecology and management) appeared to have had an impact on the teaching of chemistry. To enhance the discussion, the observations and verbal descriptions of the capacity factors found in each school were matched with characteristics of the different operational levels suggested by Rogan and Grayson (2003). The bar-graphs from the four schools were put together in figure 10.2 below so that the capacity factors can be compared.

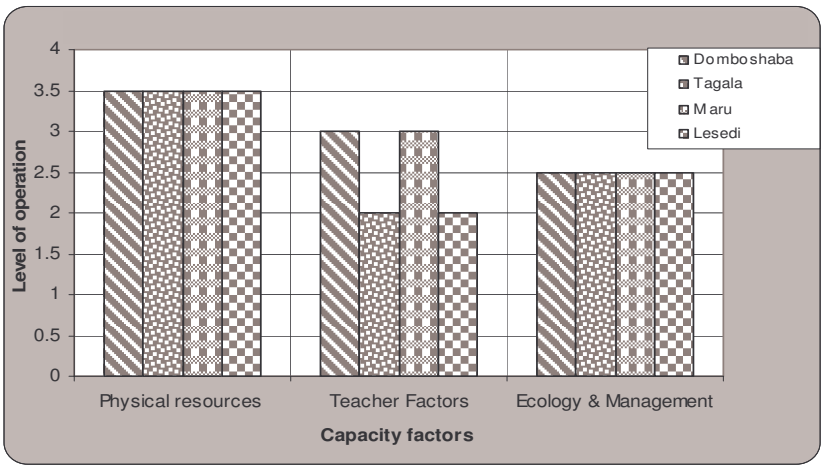


Figure 10.2: Levels of capacity to support innovation

The chart shows that infrastructure in terms of physical resources was generally superior to the teacher factors and ecology and management systems in all schools. Physical resources were very good in all schools and schools had similar resources as indicated by the same level of operation assigned to them. It has been explained why the level was set at 3.5.

Regarding physical resources, the interventions for all the schools would be in the region of operational levels above 3.5 to 4. To achieve level 4 on Rogan and Grayson's scale, the aspects which could be improved, included enriching teaching aids such as posters, improving access to photocopying and printing and improvement of sports facilities. When considering resources relating to chemistry teaching only, it becomes evident that there was not a great deal needed to reach level 4 in Rogan and Grayson's scale.

Regarding teacher factors, the graph is surprisingly low considering the fact that all teachers had a minimum of a bachelor's degree. This is possibly due to the generally low teaching experience of most teachers. Poor SMK and PCK should be expected in teachers with low teaching experience. According to Loughran et al. (2006) teachers with good content knowledge can still have low SMK and PCK due to low teaching experience or having to teach a new topic introduced by a new curriculum.

The teacher factor bars are also probably influenced by the fact that the teachers in all schools generally had low morale and were not totally committed to teaching. As a result of this lack of commitment, the majority of teachers did not seem to want to associate themselves with their schools and the BGCSE vision. They generally did not see the need to change and improvise. Hence they often gave trivial explanations to justify their low levels of practical work and learner-centred activities. Teachers saw changes and innovation as increasing their work load, hence some teachers wanted to do the minimum which amounted to teaching during allocated slots only. Only in Domboshaba SSS and Maru SSS did teachers want to be part of the departmental visions of being innovative and achieving good results. This was despite their lack of support for the school administration. In spite of such contradictory visions, in these departments the teachers collaborated with colleagues and shared teaching and learning resources.

Figure 10.2 shows the average level of operations in terms of ecology and management as 2.5 for all schools. The level was lower than for the physical resources and in some schools, lower than teacher factors. According to the teachers in all the schools, the management was not participatory, though teachers were involved in various organs within the schools. Lack of participation in decision making had led to a situation were teachers did not feel they were part of the school vision, though they had no problem showing allegiance to their senior science teachers. Senior science teachers seemed to play a bigger role in the functioning of departments than senior management, ensuring the department was innovative as well as monitoring the changes that occurred.

It could be pointed out that the low operational levels regarding ecology and management systems reflect lack of viable contributions from teachers in the affairs

of the schools. Potential areas to improve could be linked with improving the teachers' commitment to work, their morale to work and the sharing of the school vision. The degree to which they were at was found to differ by school, this could be due to support structures found in different schools. This seems to suggest that intervention strategies should be different also, and specific to individual schools. Strategies should target the areas of teachers' concern such as having a more participatory management system to help raise commitment, morale and sharing of school visions. The findings have implications too for the size of science departments due to the nature of work the senior teachers are expected to carry out in terms of mentoring, motivational and supervising teachers.

Following the discussion of the schools' capacity to support innovation, it is important to now look at the practices of the schools at the time of the study and how they compared with the capacities in schools discussed above.

10.3.2 Profile of Implementation

In previous chapters, individual teachers' practices have been discussed in detail. The operational levels were used to summarise and discuss teachers and school practices. Figure 10.3 attempts to use the average operational level of the teachers to help in explaining the operation for the school as a whole. In chapter 6, it was explained how the operational levels were amalgamated from each individual teacher's level of practice to a school's operational level. It was mentioned that to obtain the level of operation for the teachers, a match was made between indicators adapted from Rogan and Grayson (2003) and those drawn from practice. The values were later averaged to come up with levels of operation for the school (Rogan & Aldous, 2005; Rogan 2007; Hattingh et al., 2007).

The composite result giving the practice for each school in terms of classroom interactions, practical work and contexts will be discussed using figure 10.3 below.

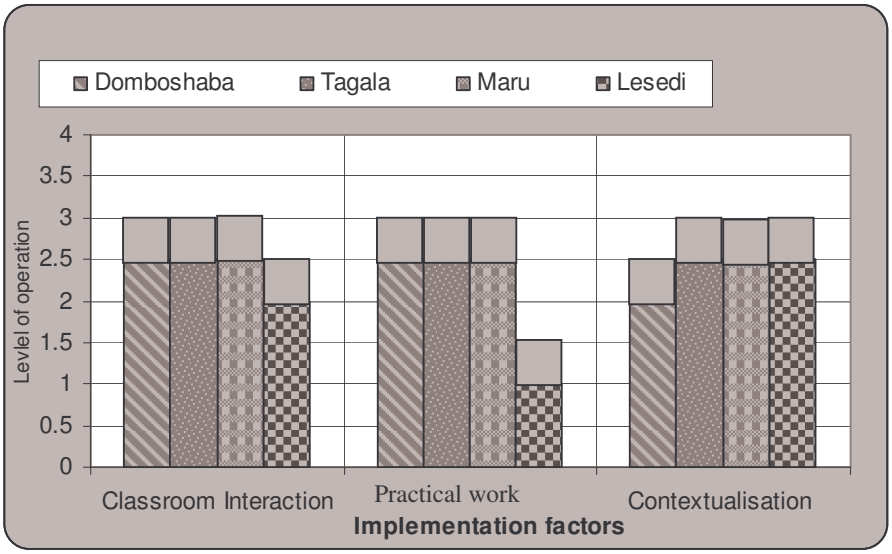


Figure 10.3: Levels of profile of implementation

Figure 10.3 show that all schools displayed low operational levels in terms of all three sub-constructs, classroom interactions, practical work and chemistry contextualisation. Apart from Lesedi SSS which was generally even lower, the other schools displayed an identical pattern. Classroom interactions have been defined as the nature of teaching and learning patterns going on inside a classroom. This includes the types of engagement learners and the teachers are involved in during the classroom discourse. Figure 10.3 shows that teachers' highest operational levels were at 2.5. This level involves components of level 2 and the additional activities which elevate it to level 2.5.

Level 2
Teachers: Textbooks used along with other textbooks**;** Engages learners with questions that encourages in depth thinking
The Practice: Probes prior learning; Structures learning activities for learners to construct own knowledge; Knowledge is made relevant, based on problem solving techniques

Level 2.5 (Additional indicators…?)
Learners: Use of additional sources of information to make notes; Engage in meaningful group activities
Make own notes on the learned activities**;** Learners introduced to the evolving nature of scientific knowledge

Figure 10.4: Excerpt from Appendix B showing a school's physical resources

It was clear from the dominating indicators drawn about the teachers that they were not always choosing learning activities involving participation by learners. For instance, in Lesedi SSS, teaching was still dominated by lengthy teacher talk as well as extensive note taking. Though it could be said that in all the schools, some teachers were on occasions able to reach level 3, the majority of them did so only rarely. Teachers preferred to engage learners in interactions fitting with levels 1 and 2. Domboshaba, Tagala and Maru SSS teachers were slightly better than those at Lesedi SSS. The better teachers were generally found to do well in terms of giving learners opportunities to participate in some form of classroom talk and hands-on activities. Maru SSS generally scored well in having more teachers and lessons operating at level 3. But it was observed that rich activities were mainly reserved for the triple science (elite chemistry) groups.

The interventions necessary to fill gaps mentioned above would be what Kelly (1999) refers to as school specific. This is so because, even though the schools appeared to operate at more or less the same levels, the finer details of what was happening in the schools or what was lacking were not the same. For instance, in Maru SSS teachers would need to extend quality teaching to all forms and science streams, whilst in Lesedi SSS, some teachers would need to elevate their teaching to match that of the most experienced teacher, Ms Nakedi. In Domboshaba SSS, teachers seemed to favour algorithmic teaching which points towards a need to raise the quality of teaching to be more learner-oriented and geared towards relational understanding.

Another aspect of curriculum implementation related to how much practical work was found in all the senior secondary schools. Figure 10.3 shows the hands-on level found in the schools. Like in the classroom interaction, drawing of operational levels for the schools followed the same pattern as above.

According to figure 10.3, Domboshaba, Tagala and Maru schools seemed to do reasonably well in terms of exposing learners to hands-on activities. It was noted earlier that the physical resources related to chemistry teaching were more than adequate in all the schools. It could thus be expected that practical work would be prevalent since there were a number of chemistry laboratories, sufficient apparatus and chemicals available for teaching. Two of the observed teachers at Maru SSS

performed more practicals than all teachers in other schools, but the third teacher at this school was not observed carrying out any practical work at all which reduced the average level for the school. In this school, practical work was mainly reserved for triple science students, unlike the other schools were all groups were exposed to such activities regardless of their science stream. The level of 2.5 for Maru SSS therefore appeared to be justified because practical work seemed to be reserved for the triple science groups only. In Lesedi SSS, none of the teachers was observed doing practical work during teaching. The only practical activity was a school based practical test for all triple science learners, organised by the science department.

It could be said that the nature of intervention needed for these schools should be chosen to fit what was observed on the ground in each school. There appears to be a need in all the schools to promote taking practical work beyond level 2.5. There is still a need for teachers to design practical work that encourages learners to discover information, engage in more group work, and to report back guided by more in-depth guiding questions (Gott & Duggan, 2007, 2002; Motswiri, 2004). It was also found that most of the teacher questions leading discussion were mainly low-order questions requiring little in-depth thinking. But given the level of available resources, it should be possible to find appropriate interventions to raise teacher capacity to a level where they are able (Motswiri, 2004).

Closely related to practical work is the concept of contextualisation in science. Figure 10.3 shows the level of contextualisation that was observed during teaching and learning of chemistry. According to the graph, teachers fared poorly. For instance, it was found that teachers at Domboshaba had difficulty in contextualising chemistry concepts. Teachers preferred to teach science concepts divorced of contexts. When they did use contextualisation, they operated at level '1' where they used applications and examples only from everyday life to illustrate scientific concepts. Teachers rarely based lessons on higher level issues which might have importance to the local community. Aspects of higher levels such as learners actively investigating the application of science and technology in their own surroundings through data gathering such as surveys were non existent. All schools generally used low forms of contexts.

Intervention would need to focus on raising the awareness of teachers of the need to use analogies, to explore scientific phenomena by different cultural groups and actively engage learners in investigating the application of science and technology in their own environment. This includes learners undertaking projects to explore long term effects of community projects, to determine the benefits and their detrimental effects (Hofstein & Kesner, 2006).

10.4 Capacity to Support Innovation and the Profile of Implementation

Following the discussion of the observed practice and the capacity levels of all the schools, it appeared logical to find out how the school practices related to the nature of capacities and support rendered to the schools. It was mentioned that capacities did not differ by much in terms of physical resources and ecologies of the schools. This seems to suggest that there are differences in certain critical areas that led to varying levels of curriculum implementations.

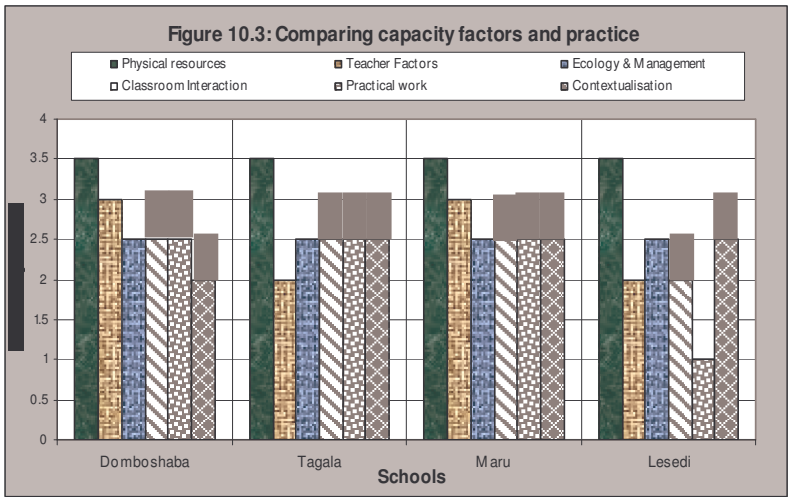


Figure 10.5: Comparing capacity factors and practice

Figure 10.5 gives a summary of the factors from capacity to innovate and curriculum implementation in the schools. Generally, levels of operations for classroom practice were lower than the levels of capacity factors. This could be a result of compilation of the operational levels for practice from individual teachers. The teacher levels used to come up with the composite operational level varied. The varying levels can also be viewed as a testament to that there is potential to raise the level of curriculum implementation with just the current infrastructure on ground. A closer look will now

be taken at the influence of the capacity factors on the practice as observed in some schools. Three broad areas have been used to illustrate such a connection.

What seemed significant in the schools was that improved physical resources especially those related to teaching chemistry, seemed not to have had any profound effects on practical work in the schools. For instance, where teachers stated that they were carrying out practical work, their reasons for doing so were related to final BGCSE practical examinations and not the availability of the resources. Availability of resources was secondary in that it was not the driving force (yet) for practical work.

According to the teachers, availability of laboratory space was a problem in all schools due to large school populations (about 1400 learners). In each school there were about 700 form 4 and form 5 learners. For each form, there were about 21 classes. This created timetabling challenges as it became impossible to slot all 42 science classes into a laboratory in a week. Considering the facilities the departments had in relation to the practical-work done, there was a discrepancy between availability of resources (facilities) and their actual use. Most teachers had missed the opportunity of using activity-based learning not because of the unavailability of resources or timetable logistics, but because the teachers themselves did not know where and how best to use them. For instance, teachers mentioned shortages of equipment merely to justify for not carrying out practical work. In some schools teachers mentioned the need for more space. But teachers were observed teaching some concepts without practical work even when they were teaching inside the laboratories with available resources. In some cases colleagues from the same school would carry out practical work, whilst the other teachers teaching the same topic would prefer to skip experiments.

It could be argued that such low levels of experimentation should have been expected since prior to upgrading of chemistry facilities, activity-based learning had not been practiced much (Prophet & Rowell, 1993). Improving facilities, according to Rogan and Grayson (2003), should not be expected to immediately lead to improvement in their use as "*exclusive focus on aspects of capacity building alone have proved unproductive*" in many situations (Rogan and Grayson, 2003; Aldous, 2005; Rogan 2007). According to them, raising resources by targeting the ZFI only where a greater

capacity already exits is likely to bring growth in a short time. Though the government of Botswana is to be commended for improving resources and localising the teaching force, young and inexperienced chemistry teachers cannot be expected to raise their practice to levels beyond their abilities. This is because of factors such as the teachers' teaching experience and their ability to handle high quality teaching activities. Incorporating level 3 and 4 practices, which is in line with the BGCSE demands, was still beyond majority of teachers. Without the development of human capacity through running workshops for teachers on laboratory work, the benefits of the resource capacities will not be realised (Kelly, 1999). More professional development intervention is needed for schools to be implemented within the ZFI of each school.

The two teachers at Tagala SSS seemed to sum up the influence or link between teacher factors and classroom practice at Lesedi and Tagala SSS. The two teachers at Tagala SSS have been described as oscillating between good teaching practice when they were comfortable with the topics and unsatisfactory when facing challenging topics. Good teaching was characterised by high learner engagement in hands-on and minds-on activities. The teachers appeared to struggle in some instances when they encountered more abstract topics. Their PCK seemed to be greatly challenged in this regard, which seemed to tie in well with the moderate level of operations in classroom interactions and practical work.

The inexperience of the two teachers was not helped by their surroundings as there was little cooperation between chemistry teachers, resulting in lack of sharing of ideas and teaching materials. This had led to a stunting of growth, as they found it difficult to settle in the science department and consequently to cope with the complexities of teaching. It seems the ecology of the department had had a more profound effect on the way they settled and eventually engaged with the craft of teaching than the physical and human resources in the school. There was no guidance from the department which encouraged teachers to do things in a similar way in this school.

The teachers in Lesedi SSS were generally not willing to give support to learners beyond teaching periods. Such a relationship seemed to suggest that the teachers did not share the school vision to attain excellent results. As one of the lower performing

schools in the country, it was not surprising that they had had a history of poor results for some time. Teachers' commitment to teaching was very low.

The management system in the school also appeared weak. According to the teachers, the new principal's presence was not felt as it had been in the past. This, coupled with teachers' unwillingness to give extra effort for learning, had not helped to improve the performance of the school. In the chemistry section, this manifested through low levels of practical work, generally low efforts to engage learners in minds and hands-on activities. The variation of teaching and learning approaches between teachers seem to suggest that teaching was not a collective effort, focused on departmental goals. Teaching and learning approaches were guided by individual ambition or abilities. This school thus showed the lowest levels of teacher factors, classroom interactions and practical work as shown in figure 10.3

Teachers at Domboshaba and Maru SSS were observed to be following teaching approaches that resembled those of other teachers and characterised by similar levels of operation. For instance, at Maru SSS, there were many signs that teachers were incorporating teaching and learning approaches in line with the desires of the department. Classroom activities were more interactive, with high participation of learners during teaching and learning. Hands-on practical activities were common and teachers attempted to contextualise concepts most of the time. At Maru SSS, a high level of learner participation was usually observed, especially in triple science streams.

Teacher factors were also evident in terms of teachers' willingness to involve learners. At Maru SSS, this involved willingness to be innovative and learn from other schools, to offer extra support to learners through science clinics or clubs and by ensuring they stayed functional and attractive to learners. Chemistry teachers at Domboshaba and Maru SSS were committed to support the learners and the department's vision by wanting to stay at the top nationally, obtaining the best chemistry results. This appears to have been the major driving force to quality support despite teachers having a negative attitude towards the management of the school.

Commitment of teachers and support extended to each other, appeared to be crucial too in their willingness to try new things. Having discussed the levels of operations and the ZFI of the schools, it was now important to come up with a summary of the intervention strategies that would be suitable for the identified gaps. The operation levels helped identify the ZFI, as it is the level immediately above operational level.

It is important to note that the ZFI concept only applies to the profile of implementation. This is so because the ZFI is based on psychological considerations and hence, it applies to human behaviour only (Vygotsky, 1978). In this study, the ZFI was presented as 0.5 as this represented the minimum advancement that could be made to bring noticeable change.

School	Curriculum Implementation	Capacity to support innovation
Domboshaba	**Classroom interactions (2); Practical work (2.5) and Contextualisation(2)** Classroom still dominated by algorithmic teaching approaches Poor preparations and poor questioning skills Individual practical work and demos given Little involvement during demos Minimal use of contexts, analogies by the teachers or use feedback from learners during teaching ***Intervention*** To improve teaching to relational understanding improve questioning skills, Internal workshops to help teachers improve	**Physical resources (3.5); Teacher Factors (3) and Ecology and Management (2.5)** Department recognised need to have printing, photocopying resources to improve efficiency Need for better organisation in the department Morale of teachers relatively low, teachers not satisfied with the work environment School management recognised by teachers as poor, leading to poor discipline of learners Teachers felt there was need to improve resources that would help preparing for tests effective; need to have a stable management system seen a route to stabilising discipline, bringing order and lifting morale of teachers
Tagala	**Classroom interactions (2.5); Practical work (2.5) and Contextualisation (2.5)** Teaching fluctuated between good and bad practices, teachers may need stabilise preparations, offer same level of quality teaching to all classes; Practical work was valued but there was no consistence in how and when it was used, ***Intervention*** *Teachers differed in their use of contexts* *Level of use of use of practical work and contextualisation could be improved to the levels of the teachers who included that; highlighting teachers' level of operation to them through workshop session could help them perform better*	**Physical resources (3.5); Teacher Factors (2) and Ecology and Management (2.5)** There is a need to reorganise the department in order to care for available resources more Teacher relations were very poor This calls for the department to be reorganised to be accommodative of mentoring of young teachers; care for resources that are available in the department
Maru	**Classroom interactions (2.5); Practical work (2.5)** and **Contextualisation (2.5)** Classroom activities were dependent on streams teachers were teaching and could go up to level 3, some teachers operated at level 2 in classroom interactions, practical work and contextualisation. ***Intervention*** *Teachers could be educated more to reach levels of more performing peers, as well as to treat learners the same way in terms of hands-on and minds-on activities.*	**Physical resources (3.5); Teacher Factors (3)and Ecology and Management *(2.5)*** The department had good infrastructure in terms of facilities and resources needed to teach chemistry, but where under utilised in some ways due to timetabling logistics, disgruntled teachers who were not happy with the school management. An improvement of the relationship between the teachers and the school management could help propel resource utilisation and morale to teach and consequently teaching in general
Lesedi	**Classroom interactions (2); Practical work (1) and Contextualisation (2.5)** Teaching was dependent on teaching experience and individualistic; experienced teacher reached highest of 3 whilst inexperienced teacher was at 1 in terms of classroom interactions. Practical work was low. ***Intervention*** *This calls for intervention to target teachers to aim for level 3 in classroom interactions and start incorporating practical work and contextualisation during teaching*	**Physical resources (3.5); Teacher Factors (2) and Ecology and Management (2.5)** Resource availability was high; teacher factors especially relating to willingness to innovate, work as a team was poor. This pulled the teachers' morale down, as well as teachers wanted to do enough. Targeting teacher factors such as building a community working together to foster a working relationship can help improve cooperation, collaboration and eventually teaching and learning.

Table 10.2: A summary of intervention guide for the schools

It is clear from the above that though schools could be rated to operate at the same levels, the requirement for improvement and what to improve might differ. However, taking the available physical resources and teacher qualifications into account it is clear that teaching practice is relatively lower than it could be predicted to be. These call for educating both old and young Botswana teachers in a modern way, so that teaching can be improved. This could be accomplished through workshops that are tailored for individual schools and not through the national workshops which are usually offered to schools.

10.5 Teacher Distribution in the Science Departments

The way teachers were physically accommodated in their departments appeared to have profound effects on the micro activities and consequently the way teaching of chemistry manifested. The science teachers' arrangements in their base rooms seemed to set the tune or code of conduct for the department or the sub-departments. Two forms of teacher distribution are portrayed in figure 10.6.

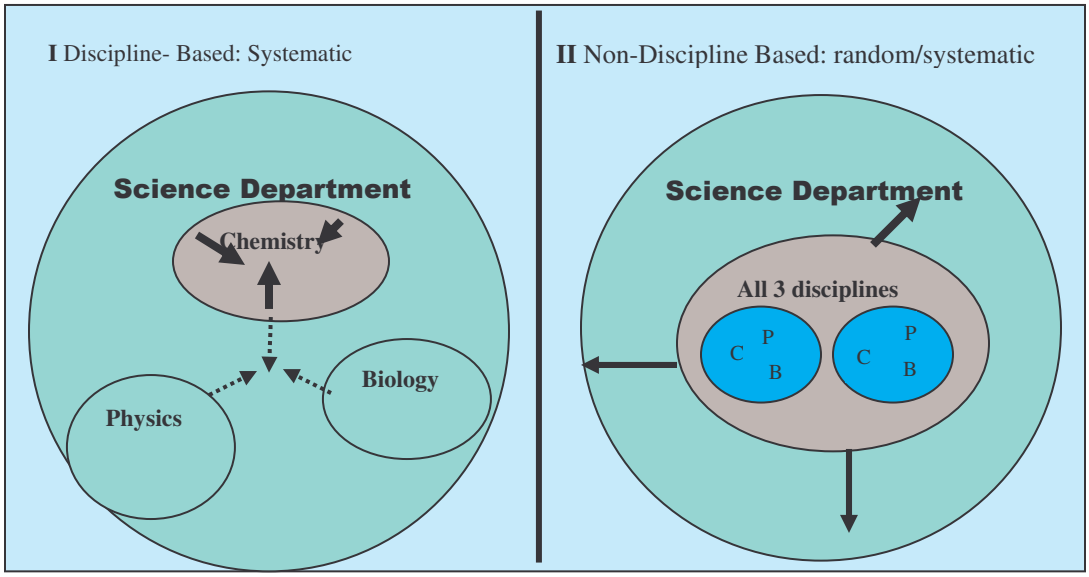


Figure 10.6: The type of teacher distribution found in the science department.

Discipline-based Distribution

The discipline-based situation was found at Maru SSS where teachers in the three science sections were totally separated from each other according to discipline. The chemistry teachers were based in one workroom where the chemistry laboratories were situated

(refer figure 5.8). Directions of arrows in the figure above show the nature of focus of the teachers. In the first diagram, decentralisation leads to a focus on chemistry. In the second diagram, the way locations were separated created a situation where science sections operated almost independently of each other. Another type of arrangement found at Domboshaba SSS was deliberate and defined along laboratory structural lines. Biology laboratories were isolated from those of physics and chemistry hence all the biology teachers were situated within the biology laboratory premises. The chemistry and physics laboratories shared a workroom as their laboratories were interconnected (fig. 5.2).

Looking closely at the first scenario where the chemistry teachers shared a workroom, it could be said that the setting seemed to bring a close working relationship between the chemistry teachers. Teachers shared ideas and materials. Chemistry teachers became closer to each other and more distant from biology and physics teachers as more of their focus was on how to improve teaching chemistry and their own work in the sub-department. The different disciplines were brought together by the senior science teacher who appeared very close to all the sections. He regularly talked informally with teachers from all disciplines during tea time. The tea club run by the science department appeared to enhance unity of the sections as all teachers met daily for tea. Coordinators of subjects also played an important role in setting the teaching tone.

Non Discipline-Based Distribution

The other format found at Tagala and Lesedi SSS followed a mixed kind of distribution. Within this setting it was observed that teachers made their own choice of where to settle, not along the line of subject discipline, but where there was working space available. At Tagala SSS, teachers placed themselves randomly within the two main workrooms, but due to availability of workspace, teachers could also find their own spaces within the science department. This created a situation where teachers were spread randomly within the science department and there was no strong force to pull different disciplines together. At Lesedi SSS, there were only two workrooms, but teachers from the three disciplines randomly placed themselves between two workplaces. Several characteristics

related to the nature of teacher distribution in the science department will now be discussed.

10.5.1 Influence of Distribution on Ecology of Science Departments

It is possible to argue that the way teachers were placed at their places of work was very important and influenced the way they worked, related to each other and developed teaching knowledge. The influences of distribution will be discussed further under the following sub-themes:

1. Order in laboratories, availability and use of resources
2. Working together
3. Influence on innovativeness - knowledge development
4. Relationship between teachers, especially the new teachers

1. Influence on Order in Departments, Availability and Use of Resources

Comparing the way teachers are distributed within the disciplines, seems to suggest that the setting had an influence on order within the department. For instance, the most united departments like in Domboshaba SSS and Maru SSS had more orderly laboratories. On the other hand the other two science departments in Tagala SSS and Lesedi SSS were found to be less organised than their counterparts.

At Maru SSS laboratories had posters (mainly commercial) displayed on the walls. Though it was not the case at Domboshaba SSS, according to the teachers this was because all laboratories were also used as base rooms. Teachers were worried about posters being vandalised by learners. Most of the used and unused equipment and materials at Domboshaba and Maru SSS were kept in storage places. Storerooms appeared very orderly as apparatus and chemicals were either stacked in trolleys or stored safely in shelves and cabinets. The departments at these schools also had a good working relationship with the ancillary staff such as the laboratory technician and attendants. In these two departments, there were no complaints about the laboratory attendants failing to carry out their duties.

It was observed that there was less order in terms of storage of equipment, used materials and apparatus. For instance, at Tagala SSS most of the equipment and materials were generally not stored in their right places (fig. 5.4). New materials and equipment that had just been purchased such as chemicals and teaching models were left idling in the unused preparation rooms. There were also no posters within the laboratories and walls but posters were stored in storerooms. In these two schools, there was a general feeling by the teachers that the laboratories were not cared for. The laboratory assistants were perceived by the teachers as very uncooperative and unwilling to carry out some of their duties.

2. Influences on Working Together (Cooperation and Collaboration)

The fact that there was such a marked link between departmental cohesion and the physical work-space of teachers seems to fit the community of practice concept put forward by Wenger (1998). Results showed that in settings that supported cohesion, interaction that occurred between the teachers provided a good environment to support the development of professional knowledge and consequently implementation of the new curriculum. The environment allowed for opportunities to discuss factors that facilitated knowledge growth. Lack of this type of discussions usually had detrimental effects on science and science learning, especially on the young and inexperienced teachers. At Tagala SSS there were even more workrooms which encouraged a greater spread resulting in less cohesion between teachers and especially ancillary science members.

According to the findings, two types of setups had emerged. The first setup which was seen to meet some of the characteristics of good practice by Wenger (1998) was observed in Domboshaba SSS and Maru SSS where teachers worked as a community of practice. This setting had to do with science teachers, but specifically chemistry teachers sharing chemistry teaching concerns which ignited the passion to do and learn to do better through close and regular interactions. Some of the characteristics previously discussed are shown by a variety of activities in the department the members developed and did together such as:

- Teachers worked positively together (both experienced and inexperienced teachers) to discuss their own lesson concerns and issues through planning together
- Teachers also assisted each other in terms of distribution of helpful teaching resources such as hand-out notes prepared by other teachers and sharing experimental setups
- In these schools there was a generally homogeneous teaching, showing that their planning closely resembled each other
- In such setups there was clarity in communication, productive group meeting procedures aimed at improving current practice. Manifestation of all these tended to reduce conflict, boost productivity and generally to help remove obstruction to efficient functioning both within and between sub-departments

The two departments introduced a mentoring scheme that had not been there before which helped the department function well. Departmental organisation included having informal contact during, for example a tea club. Such informal settings went beyond just tea as shown by the cohesion, social interaction and the types of support they extended to each other. Teachers in these schools were co-participants in departmental issues and activities. Characteristics mentioned as forming crucial ingredients for a working community were missing in Tagala SSS and Lesedi SSS setups. For instance, the desire to solve internal problems, confront those not performing their duties, sharing of resources and even information was not prevalent.

3. Influences on Growth and Learning

It could be concluded that in a format that supported a community of good practice, younger and older teachers associated with each other. Accordingly the interactions helped with development of professional knowledge. Teachers seemed to have benefited in the following areas as a result of interactions:

- General pedagogical knowledge growth
- Assessment practices
- Curriculum knowledge

Mixing of teachers appeared to facilitate general knowledge development of all the teachers in the department. Both young and experienced teachers seemed to be affected equally in terms of coping with teaching. For instance, in Maru SSS regular discussions between teachers in the chemistry section affected and benefited all the teachers. The young teacher in the group seemed to recognise competence of the experienced teachers in the department as he constantly mentioned their teaching and planning. It was often said by teachers that they all enjoyed listening to one of the oldest teachers in the department, Mr Phenyo teaching.

It could be said that in such setups, teachers used the presence and support of the older teachers for the purposes of making connections with colleagues to know that they were doing the right things. This also seemed to help in terms of meeting each other's needs, which is said to be a strong condition for knowledge development (Zembylas & Barker, 2002). For instance, teachers visiting each other's lessons like in Domboshaba SSS were able to help each others support learners. There were also opportunities for visiting teachers to have a new experience by observing what other colleagues were doing and how they did things. The same could be said about the teachers who enjoyed listening to Mr Phenyo an experienced teacher teaching as they worked in the preparation room.

4. Influence on Innovation

School visits also helped teachers find what they thought they were looking for to help them improve their areas of needs (e.g. departmental organisation and how to improve or support single science performances). The same could be said about such visits even where teachers (departments) had not identified any specific needs. Working with other colleagues or schools led to teachers identifying solutions to needs such as teaching strategies they were unaware of. Visiting neighbouring schools by Maru science teachers showed them that they could use their resources and afternoons study times better.

It was also observed that teachers at Tagala and Lesedi SSS did not want to fully commit to learners' support structures as collaboration and cooperation between teachers was poor. The experienced teachers did not share ideas, information, and resources with the

young inexperienced teachers. According to Mr Mano and Mr Mokone at Tagala SSS, the two experienced teachers stifled their growth through refusal to share and deliberate sabotage.

At Lesedi SSS the situation was not as appalling in terms of experienced teachers' ill-treatment of others. But lack of informal unifying factors meant the science department mainly performed poorly in terms of working together and making decisions. Teachers claimed that they approached each other, asked for help, but the revelation from the inexperienced teacher who appeared to have no one to turn to for support showed that cooperation was only superficial. A testament to this was revealed during a meeting, where the department attempted to map-out areas of needs. Some teachers made contributions coming up with innovative proposals such as to have learner supporting structures like operating a science club and a science clinic. The majority of teachers rejected such a move for fear of over loading their afternoons with work. It did not appear to be a well united department oriented towards learning, solving their own problems as discussions for developments were rejected without coming up with viable alternatives. This was proved further as talks to identify problem areas was not meet with equal commitment to take actions. An attempt in the past to visit other schools to help with the identification of needs areas was not successful as the administration could not finance the trips.

The level of cohesion and consequently cooperation seemed to have an impact on the way teachers cared for each other and even their own psychological health. The care extended to each other in schools was witnessed on the way duties were distributed.

Allocation of Duties

At Tagala SSS and Lesedi SSS, the significance of setups became much clearer when one looked at whether the available structures facilitated knowledge development as well as offering support for coping of the teachers. This became more conspicuous when looking at the challenges the inexperienced teachers faced during settling. Mr Mano gave the impression that he was coerced to coordinate the chemistry department. The older and

more experienced teachers were not willing to do that. What was common to all the three new chemistry teachers was that they all found it hard to fit into the system, be mentored to, to help with their development of teaching knowledge. Though a new teacher, Mr Mano coordinated the chemistry section and taught the triple science class which could be regarded as more demanding for new teachers.

Impact of Departmental Unity on Teachers' Morale

Mr Kopano's situation at Lesedi SSS was different as he was on good terms with his colleagues. Though grappling in many areas to balance his teaching, he saw no point in looking for support from colleagues. They also did not seem to know that he faced many struggles. According to Mr Maphane, an older and more experienced physics teacher in the department, young and enthusiastic teachers like Mr Kopano eventually lose steam and drown due to lack of support. Mr Maphane's words seemed to sum up the death of commitment to teachers even early in their careers. It was clear that for both chemistry sub-departments that the inexperienced teachers were not benefiting from the competence of their experienced colleagues. There was not enough cohesion to kick start inexperienced teachers approaching their experienced colleagues or vice-versa. Instead they preferred to work in isolation, which therefore limited their growth. This should be expected because all the teachers had needs they identified, but having no internal support meant some needs that could have been met internally were not.

Generally, the lack of working together increased the sense of isolation and unhappiness by the inexperienced teachers. Signs of despondence were also observed with the experienced teachers as they faced frustrating situations they could not solve alone. At Lesedi SSS, there has been a large turn-over of science teachers, with some teachers still looking for a way out. The young teachers expressed that they would prefer doing different work or teaching in another school, which was a sign of poor commitment to teaching and especially implementation of the chemistry curriculum.

10.5.2 Unifying Factors

A number of factors could be attributed to having contributed to uniting the science teachers. Informal setups like a tea-club not found in some schools, but were in Domboshaba SSS and Maru SSS had beneficial effects to science teaching as well as the development of teachers in general. Beginning teachers appeared welcome and part of a working community. This is expected as Zembylas & Barker (2002) had came up with evidence that describes beliefs of beginning teachers as liberal but also humanistic in that they value positive self-concept, warmth and caring. Lack of environments that provide care and support therefore works against teacher development and consequently science teaching and implementation.

The nature of community of practice found in Maru SSS and Domboshaba SSS departments helped both experienced and inexperienced chemistry teachers feel a sense of belonging, something that was missing in the other two schools. Inexperienced teachers generally felt less pressure to do certain duties as their older peers were responsible for more complex duties like teaching triple science, pressure to organise and do practicals for the whole section, and even leading sub-departments e.g. chemistry section. In schools where there was less mentoring, the affected teachers felt less cared for their personal and professional needs by their schools and colleagues. Therefore such setups were two fold, being of psychological health to the teachers helping them to cope or failure leading to mental break down. For instance, in Lesedi SSS, several science teachers wanted to leave teaching with a couple already having done so. At Maru SSS, some teachers were so disgruntled they talked of having wanted to help pull the results down in order to send their message across.

The Micro Components of Departments

The departmental code of conduct was described above as closely related to how teachers were situated. It could be said that the quality of working relationships forged between science teachers represent one vital aspect in the reform efforts that has gone almost unattended. Brown and Schulze (2002) have done a case study on working relationships between indigenous and expatriate teachers in Botswana. Though their study was not

science discipline oriented, it revealed ambiguity and uncertainty, interest and obligations influenced by culture and the interplay of micro-politics that expatriates and indigenous teachers bring to these relationships in ways that affects work. According to them, certain conditions have to be met on issues concerning the formation of a working relationship across culture and micro-politics in schools. It could be extrapolated to science teachers in Botswana that though they are of similar cultural background, the ambiguity, uncertainty and differing interests between teachers who are not close to each other can lead to work related problems. Teachers need to be helped to focus their attention to work by bringing them together. For example, chemistry teachers staying together had better understanding of each others' needs. This has implications on having more roles given to sectional leaders and having their duties recognised and rewarded.

Following a description of the curriculum implementation as well as the issues surrounding how teaching and learning occurred, a summary of factors which seems to influence curriculum implementation more are summarised below.

10.5.3 Influential Factors in Implementing a Chemistry Curriculum

The factors influencing the implementation of the BGCSE curriculum are pulled together here. Several factors have been identified and those that made a greater impact have been discussed in detail. These factors which are an amalgam coming from different schools are represented in a diagrammatic form below in fig. 10.7.

The teachers considered central to the implementation of the BGCSE as it is they that translate the curriculum vision into reality. This happens through finding the appropriate balance of preparation based on the curriculum goals and how they involve the learners they teach. In their endeavours, teachers were supported or hindered by the factors feeding into the teachers' functionality as identified in the figure above.

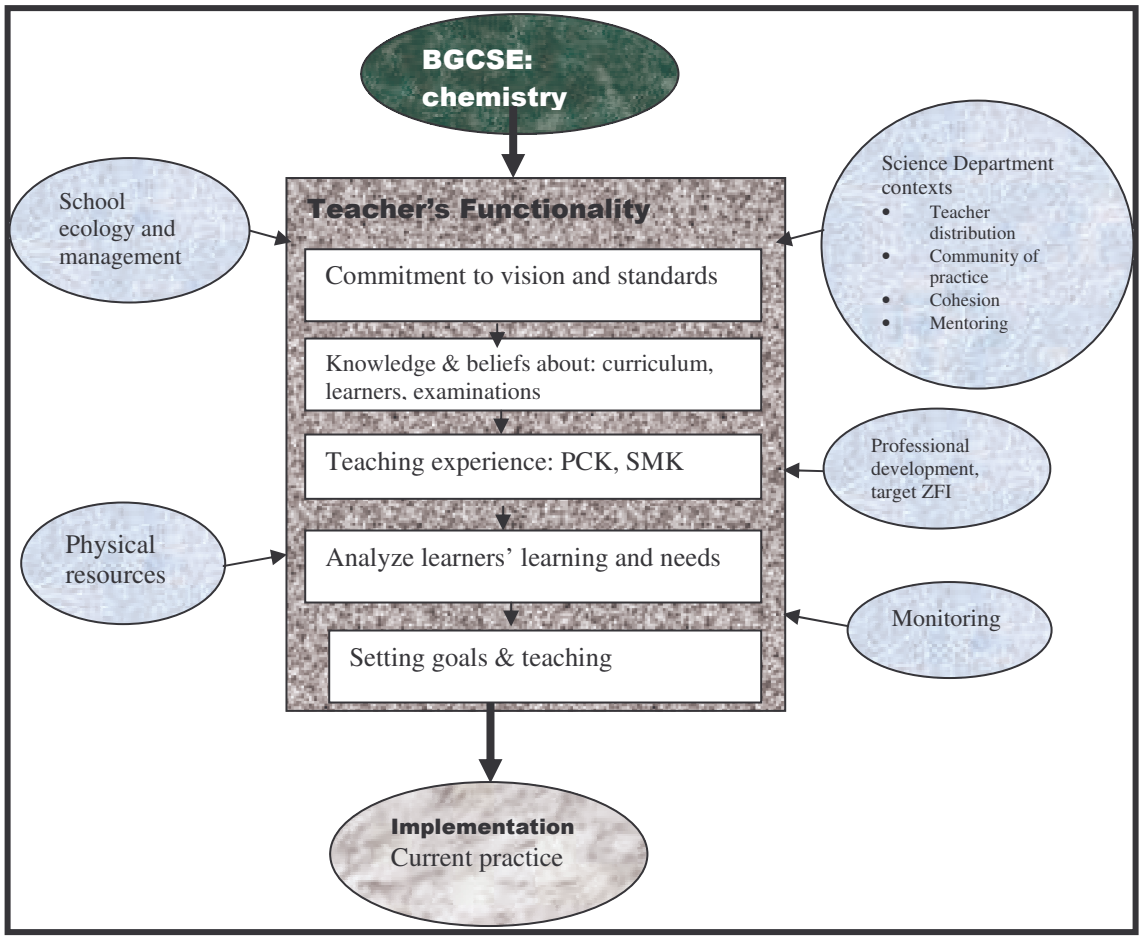


Figure 10.7: Factors influencing chemistry teaching in senior schools in Botswana

Clearly teachers and specifically what they know has the most direct impact on curriculum and on learners' learning. Curriculum interpretations and consequently learners' learning depends on teacher knowledge. Research studies confirm a close link between teacher's knowledge in science and curriculum issues and implementation as well as learners' performances (Darling-Hammond, 1998; Loucks-Horsley et al., 1998; Rogan & Grayson, 2003; Kelly, 1999; Pinto, 2005), hence the consideration of the teacher occupying central position in the diagram above.

Rogan and Grayson's model does not explicitly take the teacher as central. But a close scrutiny of the three constructs and specifically their sub-components shows that capacity to innovate has two sub-constructs directly influenced by teachers. All the sub-constructs in the profile of curriculum implementation can be said to be directly linked and

influenced by the teachers, hence, pointing towards the importance and centrality of the teacher in curriculum implementation.

It could be said implementation of a curriculum depends on knowledge about many dimensions of the teachers' contexts, to guide them in designing lessons that are appropriate and realistic while advancing the school and policy visions and goals. The findings from the empirical chapters demonstrated that implementing a curriculum is complex and that several factors were at play in Botswana senior secondary schools. This also seems to coincide with Rogan and Grayson's (2003) theory that an innovation should not come in one size-fits-all, as it needs to be reconceptualised to fit the context in which teachers teach and their learners learn. This statement manifests in various ways especially through different levels of operations as observed between teachers and schools. Differences have implications on the nature of interventions and strategies chosen to maximise implemented curriculum, as successful in one setting may fail in another. Differences in operations show that what really makes the difference is the context in which the curriculum operates.

10.6 Conclusions

The research questions were used to guide the conclusions drawn for the study. Since the central purpose of this study was to find factors in school design and organisations that best promoted new curriculum implementation, research question 3 was attempted first. Research questions 1 and 2 respectively then followed. All the questions were repeated for convenience.

10.6.1 Answers to the Research Questions

QUESTION 3: *How do designs and organisations in schools promote or inhibit new curriculum implementation in Botswana secondary schools?*

The conclusions were spilt into two parts concerning the nature of resources and communities found in schools.

All schools had good infrastructure in terms of physical resources and teaching personnel qualified to teach senior secondary school chemistry. This seemed to suggest that the schools would operate in the same way due to having similar infrastructures. It was found however that there was a general lack of technical know-how by the schools to fully utilise the resources in place. For instance, though schools appeared to have good resources, teachers continued to mention deficiencies despite the fact that some resources on the ground were not fully utilised. Teachers gave excuses such as having shortages of resources which seemed to show their own insecurities and inadequacies in utilising what was available. This is not a new phenomenon as Hattingh et al. (2007) and Rogan (2007) reported tendencies of teachers to complain of lack of science teaching material when they actually had several of those materials kept in storerooms or unopened boxes. It could be said that having adequate physical resources did not translate to quality teaching.

An important factor that appeared to influence chemistry teaching was the settings found in the science departments. Social organisation of teachers was found to greatly influence the effectiveness of teaching and how the teachers generally performed their duties. Schools that worked with greater unity were found to have more collaborative structures to enhance their work. Departmental cohesion was found to influence teachers positively in terms of high level of cooperation, sharing of ideas and the mentoring extended to inexperienced teachers. In settings were there was less unity, teachers' morale to teach was poor and conflicts were rife. Generally the spirit of collegiality and sharing of ideas and teaching material was superficial. On the contrary, united teachers were found to be more innovative as well as identifying themselves with departmental vision to do more for learners.

It was observed that what pulled the teachers together was mainly the leadership of senior science teachers and coordinators. In all the schools, the administration was viewed negatively as unsupportive to science teachers. Teacher factors, administration and nature of setups found in the schools were important in the way the school functions and eventually implements chemistry in classrooms. The findings demonstrated that one of

the major influences to successful implementation was mainly science departmental contexts. Though according to the teachers, school contexts were unfavourable, two schools managed to carry on their duties smoothly regardless of how they perceived the school authorities. Relationships with the school authorities according to the teachers were not always good, but a cordial relationship between teachers at department brought positive work attitudes.

A united community setup was observed in two science departments. This was found mainly where the teachers were distributed according to their subjects. This appeared to make the teachers more focused on their subject. The setups seemed to show that teachers did not just interact superficially at social level only such as at tea clubs, but there was more into their activities and interactions. Teachers were also involved in higher levels of engagement such as adopting innovative structures to support learners such as science clinics, science clubs and a disciplinary committee. The level of mentoring to inexperienced teachers, exchange of ideas, information and materials seemed to strengthen cooperation, collaboration and the implementation of more progressive teaching approaches (Zembylas & Barker, 2002).

The other research questions will now be attempted. Research question 1 attempted to find how the BGCSE chemistry curriculum was perceived by the chemistry teachers. Teaching chemistry was still at that time the same as it had been done in the past. Teachers did not expect major differences due to their limited knowledge and understanding of the new curriculum policy. Teachers saw major changes as having occurred in the content and syllabus structure. Hence, the majority of teachers reacted to the bulkiness of the curriculum content and not much mention of policy governing its adoption.

Research question 2 attempted to find how the teaching and learning of chemistry was conceptualised in practice by the teachers. Schools were found to teach chemistry in varying ways in the three areas used to explain classroom activities. In terms of meeting the ideals of the BGCSE curriculum, generally teachers were found to be still lagging behind in all the three areas. The ideal BGCSE had been defined as matching the highest level of the

Rogan and Grayson's (2003) operational levels. It was also found that teachers tended to raise the quality of teaching and learning when the learners involved were the triple science groups. These learners were generally exposed to more minds-on and hands-on activities.

Generally the highest level of operation in teaching reached by schools was 2.5. According to this level, teachers still had some way to go to reach the ideals of the BGCSE curriculum which was described as matching level 4 in terms of the scale devised by Rogan and Grayson (2003). Teachers' experiences also played a big role in whether teaching followed the BGCSE model. In the researched science departments, where there were more experienced teachers, higher operational levels were observed.

Other Conclusions

- The ZFI has been discussed as an important indicator of conceptualising improvement of teaching in schools. When the ZFI for each factor is identified specifically for a school, it is much more certain that implementation of a curriculum will be enhanced
- The ZFI is useful in identifying interventions needed for different schools
- Different interventions are needed for different schools
- The BGCSE is not being implemented as it should be
- The BGCSE is not being interpreted by teachers as it should be

10.6.3 Implications of Findings for Teachers, Schools and Educational Departments

Implications of the finding had been placed in three categories related to the teachers and schools practices, policy and future research. These relate to key findings regarding the ZFI, the most functional settings and how they impacted teaching.

Influence on Schools and Educational Departments

Teacher distribution was found to be crucial when it was deliberate rather than random as it had more impact on the:

- Community of science departments and teachers' practice
- Teachers' growth especially on the mentoring of the inexperienced teachers
- Innovativeness of science departments
- Teachers' work and generosity, especially sharing of ideas and materials

The notion of community of practice or distribution of science teachers had been outlined as crucial to the teachers and the department's functionality. Teacher distribution has important implications on the way science departments are run in Botswana in that there could be a need to restructure department, by deliberately distributing teachers according to subject discipline. It was found that this way, teachers become more focused on issues concerning their sections, with every member becoming a co-participant in the day-to-day running of the sections. Teachers share materials, ideas, and are more inclined to innovate and change. Looking at the gains by both the more experienced and less experienced teachers, it becomes crucial that such setups be considered.

Science Senior Teachers' Roles

Science senior teachers were found to be central to the functioning of departments. Teachers preferred to show allegiance to the senior teachers' visions than those outlined by the central administration. This seemed to suggest that the senior teachers should have bigger roles in managing, mentoring teachers and monitoring activities within science departments. This is not surprising considering the size of departments. Science departments comprises of up to 20 biology, chemistry and physics teachers. Science senior teachers therefore had bigger roles in managing a large teaching force but their roles are not recognised. This has led to a situation where some science senior teachers would carry more duties of managing sections, mentoring teachers, bringing innovations and monitoring activities or changes that are not rewarded. Their duties are even larger than those carried out by HoDs in smaller departments and even some principals in smaller schools. This has implications on the nature of science departments to be split to smaller sections as they seem to work well when administered by coordinators. But they could be more effective if such roles are recognised, thus calling for science sections to be led by senior teachers.

Impact of the ZFI on Schools and Policy

The ZFI had been described in the findings, the discussion of findings especially interventions relevant to aid the profile of implementation. Identification to the ZFI has therefore various implications to each of the factors that influence curriculum implementation or teachers' work. For instance, it can be used powerfully in the distribution of resources. Uninformed support systems to the schools can easily lead to over supply of resources as evidenced in some schools whilst some schools were under resourced. This concept can be used to help with identification of areas of needs and eventually proper distribution of resources to where they are actually needed.

Following the upgrading of the laboratories, the government of Botswana had to supply standard but basic needs such as equipment, apparatus and chemicals needed for teaching the BGCSE chemistry curriculum. But according to the teachers, lack of consultation with schools led to discrepancies due to uninformed distributions. Some differences were observed in resources such as glassware, chemicals and equipment found in the four schools. Coordination between the ministry of education (the major support for secondary school education) and schools for distributing resources appeared to have been poor. For instance some schools were over stocked with chemicals, equipment and apparatus, whilst it was possible for some schools to have shortages or no such resources at all.

10.6.4 Reflection of Study

The findings were described as having methodological implications too. For instance it was mentioned that the findings showed that the operational levels and consequently the ZFI of a school is easily affected by a lack of varied teaching experience. At Tagala SSS, only inexperienced teachers participated in the study. This made it difficult to tie classroom practice with teacher factors such as those influenced by experience especially SMK and PCK. In order to have a greater understanding of situations in Botswana, it becomes necessary to have a balanced teaching experience.

It was also mentioned that it was not clear whether teachers' low commitment to work was a result of low morale or their dislike for teaching as a profession. This was not

established in this study, but it is crucial to know if teachers' are to be assisted to grow and mature in their work. For instance, it does not help much for teachers to be offered professional development courses aimed to enhance knowledge on teaching approaches, when the teachers' interest lies elsewhere. Such identification will help determine the ZFI for proper intervention to be made.

REFERENCES

Abdl-El-Khalick, F., Boujaoude, S., Duschl, R., Lederman, N., Mamlock-Naaman, R., Hofstein, A., Niaz, M., Treagust, D. & Tuan, H. (2004). Inquiry in science education: International perspectives, *Science Education*, 88, 397-419

Aldous, C. & Rogan, J. (2003). Teachers' perceptions of the implementation of C2005 in Mpumalanga secondary schools. Proceedings of eleventh annual meeting of Southern African Association for Research in Mathematics, Science and Technology Education. University of Swaziland, Manzini, 11-15 Jan 2003: 524-531.

Aldous, C. (2004). Science and mathematics teachers' perceptions of C2005 in Mpumalanga secondary schools. *African Journal of Research in SMT Education*, 8(1), 65-76.

Aldridge, J.M., Fraser, B.J. & Huang, T.I. (1999). *Investigating classroom environments in Taiwan and Australia with multiple research methods*. In SMEC 622, Curtin University Classroom Reader.

Atkin, J.M. & Black, P. (1996). *Changing the subject: Innovations in science, mathematics and technology education.* London: Routledge.

Ball, D.L. & Cohen, D.K. (1996). Reform by the book: What is –or might be – the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher*, 25(9), 6-8.

Bassey, M. (1999). *Case study: Research in educational settings. Doing qualitative research in educational settings.* New York: Taylor & Francis, Inc.

Beeby, C.E. (1966). *The quality of education in developing countries*. Cambridge, MA: Harvard University Press.

Bennett, J. & Lubben, F. (2006). Context-based chemistry: The Salters approach. *International Journal of Science Education.* 28 (9), 999-1015.

Berg, E.V.D. (1996). *Effects of in-service education on implementation of elementary science*. Enschede: Print Partners Ipskamp.

Berman, P. & McLaughlin, M. (1977). *Federal programs supporting educational change: Vol.VIII Factors affecting implementation and continuation*, Santa Monica, CA: Rand Cooperation.

Bowyer, J., Ponzio, R. & Lundholm, G. (1987). Staff Development and Science Teaching.: An investigation to selected delivery variables. *Research in Science Teaching.* 24(9), 807-817.

Brickhouse, N.W. (1989). The teaching of the philosophy of science in secondary classrooms: Case studies of teachers' personal theories. *International Journal of Science Education*, 11, 437-449.

Brown, B.A. & Schulze, S. (2002). Development of working relationships between indigenous and expatriate teachers in Botswana: A case study. *Mosenodi*, 10(1), 3-22.

Brown, J.S., Collins, A. & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18, 32-42.

Bulte, A.M.W., Westbroek, H.B., de Jong & Pilot, A. (2006). A research approach to designing chemistry education using authentic practices as contexts, International *Journal of Science Education*, 28 (9), 1063-1086.

Burns, R.B. (1998). *Introduction to research methods*. Australia: Addison Wesley Longman.

Bybee, R.W. (1991). Science-Technology-Society in science curriculum: The policy-practice gap. Journal , 30(4). 294-302.

Cantrell, M., Kouwenhoven, W., Mokoena, T. & Thijs, G. (1993). *Bridging school and university: The Pre-Entry Science Course at the University of Botswana*. Amsterdam: VU University Press.

Carnoy, M. & Levin, H.M. (1976). *The limits of educational reform*. New York: Longman INC.

Charney, J., Hmelo, C.E., Sofer, W., Neigeborn, L., Coletta, S., & Nemeroff, M., (2007). Cognitive apprenticeship in science through immersion in laboratory practices. *International Journal of Science Education.* 29 (2), 195-213.

Chin, R. & Benne, K.D. (1969). General *strategies for effecting changes in human systems*. Human Relation Center, Boston.

Chisaka, B.C. (2002). Ability grouping in Zimbabwe secondary schools: A qualitative analysis of perceptions of learners in low ability classes. *Evaluation and Research in Education*. *16*(1), 19-33.

Clandinin, D.J. & Connelly, F.M. (1985). *Teachers' professional knowledge landscapes*. New York: Teachers College Press.

Cohen, L. & Manion, L. (1998). *Research methods in education.* London, Routledge.

Cole, R.K. & Treagust, D.F. (2003). Learner mental models of metallic bonding. A cross-age study. *Science Education*, 87 (5): 685-707.

Connelly, F.M. & Clandinin, J. (2000). Narrative understandings of teacher knowledge. *Journal of Curriculum and Supervision*, 15, 315-331.

Curriculum Blueprint: Republic of Botswana (1998). *Senior secondary school programme, Curriculum Development and Evaluation*; Ministry of Education, Gaborone.

Darling-Hammond, L. (1998). Teachers and teaching: Testing policy hypotheses from a National Commission Report. *Educational Researcher*, 27(1), 5-15.

de Feiter, L.P., Vonk, H., & van den Akker, J. (1995). *Towards more effective science teacher development in Southern Africa*. Amsterdam: University Press.

Dekkers, P. (2003). The entry level of participants in UNIN's ACE programme for science teachers. Proceedings of eleventh annual meeting of Southern African Association for Research in Mathematics, Science and Technology Education. University of Swaziland, Manzini, 11-15 Jan 2003: 695-701.

Denzin, N.K. & Lincoln, Y.S. (2000). *Handbook of Qualitative Research*. London, SAGE Publications Inc.

Dlamini, B.T., Rollnick, M. & Bradley, J. (2001). Typologies of teacher change: A model based on a case study of eight primary school teachers who used an STS approach to teaching of science. *Proceedings of ninth annual meeting of Southern African Association for Research in Mathematics, Science and Technology Education.* Universidade Eduardo Mondlane, Maputo, 17-20 Jan 2001: 375-383.

Dlamini, G.S. (1998). *The role of the headmaster in meeting and a culture that enhances school effectiveness*: A case study on effective school leadership in Swaziland (masters thesis)

Driver, R., Leach, J., Millar, R. & Scott, P. (1997). Y*oung people's image of science*. Buckingham: Open University Press.

Duit, R. & Confrey, J. (1996). Reorganising the curriculum and teaching to improve learning in science and mathematics. In (Eds.), D. Treagust, R. Duit & B. Fraser.

Improving Teaching and Learning in Science and Mathematics. 79-93. Teachers College Press: New York.

English, F.W. & Larson, R. (1996). *Curriculum Management for educational and social service organizations*. Illinois: Charles C Thomas Publishers, LTD.

Fensham, P. (1987). *Development and dilemmas in science education*. The Falmer Press: London.

Fensham, P. (1994). Beginning to teach chemistry. In (Eds.), P. Fensham, R. Gunstone and R. White. *The content of science*. (1-28). The Falmer Press: London.

Fensham, P. Gunstone, R. & White, R. (1994). Science content and constructivism views of learning and teaching. In (Eds.), P.J. Fensham, R. Gunstone and R. White. *The content of science. (1-8)*. Falmer Press: London.

Fraser, B.J. & Tobin, K.G. (1991). Combining qualitative and quantitative methods in classroom environment research. In (Eds.), B.J. Fraser and H.J. Walberg. *Educational environments: evaluation, antecedents and consequences* (271-291). Pergamon Press, London.

Freyberg, P. (1996). Implications for curriculum and teacher education. In (Eds.), R. Osborne and P. Freyberg. *Learning in science: The implications of children's science*. 125-136. Heinemann Education: Auckland.

Fullan, M. (1993). *Change Force: Probing the depths of educational reform*. London: The Falmer Press.

Fullan, M. (1998). *Change Forces: Probing depths of educational change*. London: The Falmer Press

Fullan, M. (2001). *The new meaning of educational change*. New York: Teachers College Press.

Gall, M.D., Borg, W.D. & Gall, J.P. (1996). *Educational research: An introduction.* Longman: New York.

Gallagher, J.J. (1991). Perspective and practicing secondary school science teachers' knowledge and beliefs about the philosophy of science. *Science Education,* 75, 121-133.

Gallagher, J.J. (1996). Implementing teacher change at the school level. In (Eds.), D. Treagust, R. Duit & B. Fraser. *Improving Teaching and Learning in Science and Mathematics*. p222-231. Teachers College Press: New York.

Garegae, K.G. (2003). The effect of Technology on the Mathematics Curriculum. *Mosenodi*, 2(1), 27-37.

Geddis, A.N. & Wood, E. (1997). Transforming subject matter and managing dilemmas: A case study in teacher education. *Teaching and Teacher Education,* 13, 611-626.

Gess-Newsome, J. & Lederman, N.G. (9999). *Examining Pedagogical Content Knowledge.* Dorderecht: Kluwer Academic Publishers.

Ghesquière P., Moors G., Maes B., & Vandenberghe R. (2002) Implementation of Inclusive Education in Flemish Primary Schools: a multiple case study. *Educational Review*, 54, (1), 47-56

Gilbert, J.K. (2006). On the nature of 'Context' in Chemical Education. *International Journal of Science Education.* 28 (9), 957-976.

Gott, R. & Duggan, S. (2002). Problems with the assessment of performance in practical science: which way now? *Cambridge Journal of Education*, 32(2), 183-201.

Gott, R. & Duggan, S. (2007). A framework for practical work in science and scientific literacy through argumentation, *Research in Science and Technological Education*, 25(3), 271-291

Grant, S.G. (2000). Teachers and tests: Exploring teachers' perceptions of changes in New York State Testing Program. Online Available: http://www4.nas.edu/nas/nas/nashhome.nsf/WebLink/scienceeducaiton, Nov 2000.

Gunstone, R.F. (1994). The importance of specific science content in the enhancement of metacognition. In (Eds.), P.J. Fensham, R.F. Gunstone and R.T White. *The content of science, (131-146)*. Falmer Press: London.

Guskey, T.R. (2002). Professional development and teacher change. *Teachers and Teaching: Theory of Practice*. 8(3-4): 381-389.

Gustafson, B., Guilbert, S. & Macdonald, D. (2002). Beginning elementary science teachers: Developing professional knowledge during a limited mentoring experience. *Research in Science Education. 32*(3), 281-302.

Gustafson, B.J. & Rowell, P.M. (1995). Elementary pre-service teachers' contrasting conceptions of learning science, teaching science and the nature of science. *International Journal of Science Education*, 17(5), 587-605.

Guthrie, G. (1980). Stages of educational development? Beeby revisited? *International Review of Education*, 26, 411-438.

Guthrie, G. (1986). Current research in developing countries: The impact of curriculum reform on teaching. *Teaching and teacher education*, 2(1), 81-89.

Hall, K. (2002). Co-constructing subjectivities and knowledge in literacy class: An Ethnographic-Sociocultural perspective. *Language and Education*, 16(3), 178-194.

Hand, B. (1996). Diagnosis of teachers' knowledge bases and teaching roles when implementing constructivist teaching/learning approaches. In (Eds.), D. Treagust, R. Duit & B. Fraser. *Improving Teaching and Learning in Science and Mathematics*. 212-221. Teachers College Press: New York.

Hargreaves, A. & Dowe, R. (1990). Paths of professional development: Contrived collegiality, collaborative culture, and the case of peer coaching. *Teaching and teacher education*, 6(3), 227-241.

Hargreaves, A. (1992). Cultures of teaching: A focus for change. In A. Hargreaves & M.G. Fullan (Eds.). Understanding teacher development (p216-240). London: Cassel.

Hatch, J.A. (2002). *Doing Qualitative research in educational settings*. Sunny: New York.

Hattingh, A., Aldous, C. & Rogan, J. (2007). Some factors influencing the quality of practical work in science classrooms. *African Journal on SMT Education*, 11(1)75-90.

Havelock, R.G. & Zlotolow, S. (1995). *The change Agent's Guide*. New Jersey: Educational Technology Publications.

Havelock, R.G. (1973). The change agent's guide to innovation in education. Educational Technology, New Jersey.

Havelock, R.G. (1977). Solving educational problems: the theory and reality of innovation in developing countries, United Nations Educational Scientific and Cultural Organization, Paris.

Hewson, P.W. (1996). Teaching for Conceptual Change. In (Eds.), D. Treagust, R. Duit & B. Fraser. *Improving Teaching and Learning in Science and Mathematics*. 131-140. Teachers College Press: New York.

Hewson, P.W., Kahle, J.B., Scantleybury, K. & Davies, D. (2001). Equitable science education in urban middle schools: Do reform efforts make a difference? *Journal of Research in Science Teaching*, 38 (10), 1130-1144

Hitchcock, G. & Hughes, D. (1995). *Research and the teacher: A qualitative introduction to school-based research.* Rutledge, London.

Hodson, D. (1992). Assessment of practical work. *Science and Education*, 1, 115-144.

Hodson, D. and Hodson, J. (1998). Science education as enculturation: Some implications for practice. *School Science Review*, 80 (290). Online Available: http://www.ase.org.uk/publish/jnews/ssr/hodsonsep98/html, Nov 2000.

Hofstein, A. & Kesner, M. (2006). Industrial chemistry and school chemistry: Making chemistry more relevant. *International Journal of Science Education.* 28 (9), 1017-1039.

Hopkins, D. and MacGilchrist, B. (1998). Development planning for pupil achievement. *School Leadership and Management*, 18, 409-424.

Hord, S. (1987). Evaluating Educational Innovation. Croom Helm, New York.

Hyman, R.T. (1980). *Improving Discussion Leadership.* New York: Columbia Univ., Teachers College Press.

Jansen, J.D. (1999). Lessons learned (and not learned) from the OBE experience. Keynote *address, Western Cape Education Department Conference, Stellenbosch: December*.

Jegede, O.F. (1997). School science and the development of scientific culture: A review of contemporary science education. *International Journal of Science Education.* 19(1), 1-20.

Johnson, S., Monk, M and Hodges, M. (2000). Teacher development and change in South Africa: a critique of the appropriateness of transfer of north/west practice. *Compare*, 30, 179-192.

Kelly, A.V. (1999). *The curriculum: Theory and Practice*. London, Paul Chapman Publishing Ltd.

Koosimile, A.T. (2002). Access negotiation and curriculum change: Lessons from Botswana. *Qualitative Studies in Education*, 15(2), 205-223.

Koosimile, A.T. (2004). Out-of-school experiences in science classes: problems, issues and challenges in Botswana. *International Journal of Science Education*, 26(4), 483-496.

Koosimile, A.T. (2005a). Induction of pupils into secondary school science in Botswana. Sabinet Online, 9(1), 39-48. http://www.sabinet.co.za/abstracts/saarmste/saarmste_v9_n1_a5.xml, July 2008.

Koosimile, A.T. (2005b). Teachers' experiences with an adapted IGCSE physics syllabus in Botswana. *International Journal of Educational Development*, 25, 209-219.

Lantz, O. & Kass, H. (1987). Chemistry teachers' functional paradigms. *Science Education*, 71(1), 117-134.

Lave, J. & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge, England: Cambridge University Press.

Lave, J. (1996). Teaching, as learning, in practice. Mind*, Culture, and Activity* 3(3), 149-164.

Layton, D. (1986). Science education and values in education – an essential tension. In J. Brown, A Copper and F Zeldin (Eds), *Science Schools*. Philadelphia: Open University.

Lederman, N.G. (1992). Teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*, 29, 331-359.

Lelliott, A., Wakapenda, W., Doidge, M., du Plessis, J., Mholo, M., Msimaga, A., Mundalamo, F., Nakedi, M. and Bowie, L. (In Press). Issues of teaching and learning in South Africa: disjunction or dysfunction? *African Journal of Research in Mathematics, Science and Technology Education*.

Levin, H.M. & Lockheed, M.E. (1993). *Effective schools in developing countries.* London: Falmer Press.

Levin, H.M. (1987). Accelerated schools for the disadvantaged. *Educational Leadership*, 44(6), 19-21.

Lewin, K. & Hui, X. (1989). Rethinking revolution: reflections on China's 1985 educational reforms, *Comparative Education*, 25(1), 7-17.

Lewin, K. (1985). Quality in Question: A new agenda for curriculum reform in developing countries. *Comparative Education*. 21(2), p117-133.

Lewin, K. (1990). *Financing Secondary Education in Developing Countries: strategies for sustainable growth*. UNESCO, Paris.

Lewin, K. (1992). *Science education in developing countries: issues and perspectives for planners*. UNESCO, Paris

Lincoln, Y.S., & Guba, E.G. (1985). *Naturalistic Inquiry*. Newbury, CA: Sage.

Loucks-Horsley, S., Hewson, P.W., Love, N. & Stile, K.E. (1998). *Designing professional development for teachers for science and mathematics.* Thousand Oaks, CA: Corwin Press.

Louden, W. (1991). *Understanding teaching.* London: Cassel.

Loughran, J., Berry, A. & Mulhall, P. (2006). *Understanding and developing science teachers' pedagogical content knowledge*. Rotterdam, Sense Publishers.

Loughran, J., Mulhall, P. & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching*, 41(4), 370-391.

Lubben, F., Campbell, B. & Dlamini, B. (1995). In-service support for a technological approach to science education. Overseas Development Administration (ODA) *Educational Papers, No.16*. London, UK.

Lubben, F., Campbell, B. & Dlamini, B. (1996). Contextualising science teaching in Swaziland: Some student reactions. *International Journal of Science Education*, 18(3), 311-320.

Lubben, F., Campbell, B. & Dlamini, B. (1997). Achievements of Swazi students learning through everyday technology. *Journal of the Southern African Association for Research in Mathematics and Science Education*, 1(1), 26-40.

Lumpe, A.T., Haney, J.T. & Czerniak, C.M. (1998). Science teacher beliefs and intentions to implement science-Technology-Society (STS) in the classroom. *Journal of Science Teacher Education*, 9, 1-24.

Maboyi, T. R. & Dekkers, P. (2003). Science teacher's purposes for doing practical work- Does professional development make a difference? *Proceedings of eleventh annual meeting of Southern African Association for Research in Mathematics, Science and Technology Education.* University of Swaziland, Manzini, 11-15 Jan 2003: 721-727.

Macdonald, M.A. & Rogan J.M. (1990). Innovation in South-African science education (part 2): Factors influencing the introduction of instructional change. *Science Education*, 74(1), 119-132.

Malone, J.A., Atweh, B. & Northfield (1998). *Research and supervision in Mathematics and Science education.* London: Lawrence Erlbaum Associates, Publishers.

Marshall, C. & Rossman, G.B. (1989). *Designing qualitative research*. SAGE Publications, Inc.: California.

Mayer, V.M. (2002). *Global science Literacy: Science and Technology Library*. Dorderecht: Kluwer Academic Publishers.

McLaughlin, M.L. & Marsh, D.D. (1978). Staff development and school change. *Teachers College Record*, 80, 69-94.

McMillan, J., H., & Schumacher, S. (2006). *Research in Education: Evidence-Based Inquiry*. Cape Town: Pearson Education, Inc.

Miles, M.B. & Huberman, A.M. (1994). *An expanded sourcebook: Qualitative data analysis*. London, SAGE Publications.

Millar, R. (1991). A Means to an end: The role of processes in science education. In B.E. Woolnough (Ed.), *Practical Science*, Open University Press, Buckingham.

Ministry of Education (2000). *Senior Secondary School Syllabus*: Chemistry. Gaborone: Government Printer.

Mortimer, E.F. & Scott, P.H. (2003). *Meaning making in secondary science classrooms*. Maidenhead: Open University Press.

Motswiri, M.J. (2004). *Supporting chemistry teachers in implementing formative assessment of investigative practical work in Botswana*. Enschede: PrintPartners Ipskamp.

Muwanga-Zake, J.F. (2000). Is science education in South Africa in a crisis? The Eastern Cape experience. *Journal of the Southern African Association for Research in Mathematics, Technology and Science Education*. 4(1), 1-11.

Naidoo, P. (2003). Why some schools perform well in physical science in South Africa? Proceedings of eleventh annual meeting of Southern African Association for Research in Mathematics, Science and Technology Education. University of Swaziland, Manzini, 11-15 Jan 2003: 205-213.

Newton, P., Driver, R. & Osborne, J. (1999). The place of argumentation in the pedagogy of school science. *International Journal of Science Education*, 21, 553-576.

Nganunu, M. (1988). An attempt to write curriculum with social relevance for Botswana. *International Journal for Science Education*, 10(4), 441-448.

Northfield, J., Gunstone, R. & Erickson, G. (1996). A constructivist perspective on science teacher education. In (Eds.), D. Treagust, R. Duit & B. Fraser. *Improving Teaching and Learning in Science and Mathematics.* 212-221. Teachers College Press: New York.

Novak, J.P. (2002). Meaningful learning: The essential factor for conceptual change in limited or inappropriate prepositional hierarchies leading to empowerment of teachers. *Science Education*. 86(4), 548-571.

Ogunniyi, M. (1995). The development of science education in Botswana. *International Journal of Science education*, 79(1), 95-109.

Ogunniyi, M.B. (1986). Two decades of science education in Africa. *Science Education*. 70(2), 111-122.

Ogunniyi, M.B. (1995). Improving science and mathematics curriculum in African schools: A synopsis. In C. Stoll, L. de Feiter, H. Vonk, & J. van den Akker (Eds.), *Improving science and mathematics teaching in southern Africa: Effectiveness of interventions – Proceedings of a regional conference in Windhoek, Namibia*. Amsterdam: VU University Press.

Ogunniyi, M.B. (1998). Effects of science and technology on traditional beliefs and cultures. In (Eds.), M.B. Ogunniyi. *Proceedings of a Southern African Conference: Promoting Public Understanding of Science and Technology in Southern Africa.* University of Cape Town, Cape Town, 4-7 Dec 1996: 38-48.

Opie, C. (2005). *Doing Educational Research: A guide to first time researchers*. London: SAGE Publications Ltd.

Ornstein, A.C. & Hunkins, F. (1998). *Curriculum Foundations, Principles and Issues.* Boston: Allyn and Bacon.

Pabale, M.F. and Dekkers, P. (2003). Science Teachers' Views on Outcome-Based Education: Partial evaluation of UNIN's Advanced Certificate in Education Programme. *Proceedings of eleventh annual meeting of Southern African Association for Research in Mathematics, Science and Technology Education.* University of Swaziland, Manzini, 11-15 Jan 2003: 734-740.

Pekmez, E.S., Johnson, P. & Gott, R. (2005). Teachers' understanding of the nature and purposes of practical work. *Research in Science and Technological Education*. 23 (1), 3-23.

Penick, J.E. & Yager, R.E. (1986). Trends in science education: some observations of exemplary programmes in the United States. *International Journal of Science Education*, 8(1), 1-8.

Pilot, A. & Bulte, A.M.W. (2006a). The use of 'Contexts' as a challenge for the chemistry curriculum: Its successes and the need for further development and understanding. *International Journal of Science Education.* 28 (9), 1087-1112.

Pilot, A. & Bulte, A.M.W. (2006b). Why do you 'Need to Know': Context-based education. *International Journal of Science Education*, 28 (9), 953-956.

Pinto, R. (2005). Introducing curriculum innovations in science: Identifying teachers' transformations and the design of related teacher education. *International Science Education,* 89 (1), 1-12

Prophet, R.B. & Rowell, P.M. (1993). Coping and control: science teaching strategies in Botswana. *Qualitative Studies in Education, 6(3*), 197-209.

Prophet, R.B. & Thapa, A.N. (1999). Paradigm lost or Paradigm gained? The process skills approach to primary science. Science Technology and Mathematics Education in Africa: Selected papers from the Second Sub-regional Conference on Public Understanding of Science and Technology. Grand Palm Hotel, Gaborone, 6-9. Dec 1999: 51-69.

Prophet, R.B. & Towse, P. (1995). Non-technical words in science: A comparative study. *Southern Africa Journal of Science Education*. 2(1/2), 19-31

Prophet, R.B. & Vlaardingerbroek, B. (2003). The relevancy of secondary school chemistry education in Botswana: a cognitive development status perspective. *International Journal of Educational Development.* 23(2003), 275-289.

Prophet, R.B. (1995). Views from the Botswana junior secondary school classroom: Case study of a curriculum intervention. *International Journal of Educational Development*, 15(2), 115-125.

Reid, D.J. & Hodson, D. (1989). *Special needs in ordinary schools: Science for all*. London: Cassell Educational Limited.

Republic of Botswana (1977). *Education for Kagisano: Report of the National Commission on Education*. Gaborone: Government Printer.

Republic of Botswana (1993). *The Revised National Policy on Education 1993*. Gaborone: Government Printers.

Republic of Botswana (1997). *Towards prosperity for all – long term vision for Botswana (Vision 2016).* Gaborone: Government Press.

Republic of Botswana: chemistry syllabus (1998). *The Botswana General Certificate of Secondary Education.* Gaborone: Department of Curriculum and Evaluation.

Republic of Botswana: Education Statistics (2003). *Central Statistics Office - Education Statistics 2003.* Gaborone: Government Printers.

Republic of Botswana: Education Statistics (2004). *Central Statistics Office* -. Gaborone: Government Printers.

Rogan, J.M & Aldous, C. (2005). Relationship between the constructs of a theory of curriculum implementation. *Journal of Research in Science Teaching*, 42 (3), 313-336.

Rogan, J.M. & Grayson, D.J. (2003). Towards a theory of curriculum implementation with particular reference to science education in developing countries. *International Journal of Science Education.* 25 (10), 1171-1204.

Rogan, J.M. (2004). Out of the frying pan…?: Case studies of the implementation of curriculum 2005 in some classrooms. *African Journal of Research in Mathematics, Science and Technology Education*, 8, 165-179.

Rogan, J.M. (2007). An uncertain harvest: A case study of implementation of innovation. *Journal of Curriculum Studies*, 39(1), 97-121.

Ross, A.R. & Lewin, K.M. (1992). Science kits in developing countries: an appraisal of potential. UNESCO, Paris.

Roth, M.W. (1995). *Authentic school science: Knowing and learning and in open-inquiry science laboratories*. Dordrecht, The Netherlands: Kluwer.

Roth, M.W. (1997). From Everyday science to science education: How science and technology studies inspired curriculum design and classroom research. *Science Education*, 6, 373-396.

Rowell, P. & Prophet, R.B. (1990). Curriculum-in-action: The practical dimension in Botswana classrooms. *International Journal of Education Development, 10(1)*, 17-26.

Rowell, P. (1990). Feeling free to learn. In C.W. Snyder Jr., & P.T. Ramatsui (Eds.), *Curriculum in the classroom* (pp88-108). Gaborone: Macmillan.

Sadovnik, A.R., Cookson, P.W. & Semel, S.F. (2001). *Exploring Education: An introduction to the foundations of education*. Allyn and Bacon: Boston

Schumacher, S. & McMillan, J.H. (1993). *Research in Education: A conceptual introduction*. HarperCollins College Publishers: New York.

Schwartz, A.T., (2006). Contextualised chemistry education: The American experience. International *Journal of Science Education*, 28 (9), 997-998.

Sebonego, M.M. (1994). *Report of a study: child abuse and neglect,* B.Ed. dissertation, Department of Sociology, University of Botswana.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. Educational Researcher, 27(2), 4-13.

Shulman, L.S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14

Shulman, L.S. (1987). Knowledge and teaching: foundations of the new reform. *Harvard Educational Review*, 57, 1-22.

Shumba, A. & Moorad, F. (2000). A note on the laws against child abuse in Botswana. *Pula: Botswana Journal of African Studies*, 1(14), 172-177

Stake, R.E. (1978). Case studies in science education: Volume II Design, Overview and General Findings. US Government Printing Office, Washington, D.C.

Stenhouse, L. (1975). An *introduction to curriculum research and development.* Oxford: Heinemann Educational Books.

Tabulawa, R. (1997). Pedagogical classroom practice and social context: the case of Botswana. *International Journal of Educational Development, 17(2)* 189-204.

Tafa, E.M. (2002). Corporal punishment: The brutal face of Botswana' authoritarian schools, *Educational Review*, 53 (1), 17-26.

Taiwo, A.A. (1999). *Perspectives on Science Teacher Education in Africa in the Third Millennium.* Science Technology and Mathematics Education in Africa: Selected papers from the Second Sub-regional Conference on Public Understanding of Science and Technology. Grand Palm Hotel, Gaborone, 6-9. Dec 1999: 134-149.

Tesch, R. (1990). Qualitative research: Analysis types and software tools. New York: Falmer.

Thijs, A.M. (1999). *Supporting science curriculum reform in Botswana: The potential of peer coaching.* Doctoral dissertation. Enschede: PrintPartners Ipskamp.

Tobin, K. (1996). Analytical and holistic approaches to research on teacher education. In (Eds.), D. Treagust, R. Duit & B. Fraser. *Improving Teaching and Learning in Science and Mathematics*. 175-189. Teachers College Press: New York.

Tobin, K., Tippins, D.J. & Gallard, A.J. (1994). Research on instructional strategies for teaching science. In D.L. Gabel (Ed.), *Handbook of Research on science teaching and learning* (pp45- 93). New York: Macmillan.

Tsai, C.C. (2001). A science teacher's reflections and knowledge growth about STS instruction after actual implementation. *Science Education*, 86(1), p23-41.

Van Bueren, G. (1995). *The International Law on the Rights of the Child,* London, Martinus Nijhoff Publishers.

Van den Akker, J. (2003). Curriculum perspectives: An Introduction. In J. van den Akker, W. Kuiper, & U. Hameyer (Eds.), *Curriculum landscapes and trends* (p1-10). Dordrecht: Kluwer Academic Publishers.

Van Maarseven, C. (1995, December). The *composition of the mathematics and science teaching force in Botswana*. The regional conference on Improving Science and Mathematics Teaching in Southern Africa, Windhoek, Namibia.

Verspoor, A.M. & Wu, K.B. (1990). *Textbooks and educational development*. Educational and Employment Division, Population and Human Resources Department, PHREE background paper series No. PHREE/90/31: Washington DC. The World Bank.

Verspoor, A.M. (1989). *Pathways to change: Improving the quality of education in developing countries.* Washington, DC: Harvard University Press.

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological process*. Cambridge, MA: Harvard University Press.

Wenger, W. (1998). *Communities of practice: Learning, Meaning, and Identity*. Cambridge: Cambridge University Press.

Wertsch, J.V. (1985). *The Zone of Proximal Development: Some conceptual issue*s.

Yager, R.E. & Penick, J.E. (1986). Perceptions of four age groups towards science classes, teachers and value of science. *Science Education*, 70(4), 355-363.

Yager, R.E. & Tamir, P. (1993). STS approach: Reasons, intensions, accomplishments, and outcomes. *Science Education*, 77, 637-658

Yager, R.E. (1986). Searching for excellence. Journal of Research in Science Teaching, 23(3), 209-217.

Yager, R.E., & Weld, J.D. (1999). Scope, sequence and coordination: The Iowa Project, a national reform effort in the USA. *International Journal of Science Education*, 21, 169-194.

Yandila, C.D. (1999). *Knowledge base of science teachers.* Science Technology and Mathematics Education in Africa: Selected papers from the Second Sub-regional Conference on Public Understanding of Science and Technology. Grand Palm Hotel, Gaborone, 6-9. Dec 1999: 159-179.

Yandila, C.D. (2001). *The new senior secondary school science syllabuses in Botswana.* Paper presented at the 4th Biennial Conference on Teacher Education in Botswana, Gaborone: Botswana.

Yin, R.K. (1994). *Case study research: Design and methods*. Beverly Hills, CA: Sage

Yoloye, E.A. (1986). The relevance of educational content to national needs in Africa *International Review of Education*,

Yoloye, E.A. (1998). *Historical perspectives and their relevance to present and future practice*,

Zembylas, M. & Barker, H.B. (2002). Preservice teacher attitudes and emotions: Individual spaces, community conversations and transformations. *Research in Science Education. 32*(3), 329-351.

Zevenbergen, R. (1998). Ethnography in the classroom. In (Eds.), J.A. Malone, B. Atweh & J.R. Nothefield. *Research supervision in mathematics and science education.* (19-38): Lawrence Erlbaum Associates Publishers: New Jersey.

Appendix A: Rogan and Grayson - Profile of Curriculum Implementation

Level	Classroom Interaction	Science Practical Work	Science and society
1	**Teacher** Presents content in a well organised, correct and well sequenced manner, based on a well designed lesson plan. Provides adequate notes Uses textbook effectively. Engages learners with questions **Learners** *Stay attentive and engaged* *Respond to and initiate questions*	Teachers uses classroom demonstrations to help develop concepts Teacher uses specimens found in the local environment to illustrate lessons	Teacher uses examples and application from everyday life to illustrate concepts *Learners ask questions about science in the context of everyday life*
2	Teacher Textbooks are used along with other resources Engages learners with questions that encourages in depth thinking **Learners** *Use additional (to textbook) sources of information in compiling notes* *Engage in meaningful group work* *Make own notes on the concepts learned from doing these activities*	Teacher uses demonstrations to promote a limited from of inquiry *Some learners assist in planning and performing the demonstrations* *Learners participate in closed practical work* *Learners communicate data using graphs and tables*	Teacher bases a lesson (s) on a specific problem or issue faced by the local community *Teacher assists learners to explore the explanations of scientific phenomena by different cultural groups*
3	**Teacher** Probes learners' prior knowledge Structures learning activities along 'good practice' lines– knowledge is constructed, and is based on problem solving techniques. Introduces learners to the evolving nature of scientific knowledge **Learners** *Engage in minds-on leaning activities* *Make own notes on the concepts learned from doing these activities*	Teacher designs practical work in such a way as to encourage learner discovery of information *Learners perform 'guided discovery' type practical work in small groups, engaging in hands-on activities* *Learners can write a scientific report in which they can justify their conclusions in terms of the data collected*	*Learners actively investigate the application of science and technology in their own environment, mainly by means of data gathering methods such as surveys. Examples here might include an audit of energy use or career opportunities that require a scientific background*
4	**Learners** Take responsibility for their own learning; partake in the planning and assessment of their own learning Undertake long term and community-based investigations projects **Teacher** *Facilitates learners as they design and undertake long-term investigations and projects* *Assists learners to weigh up the merits of different theories that attempt to explain the same phenomena*	Learners design and do their own 'open' investigations. They reflect on the quality of the design and collected data, and make improvements Learners can interpret data in support of competing theories or explanations.	Learners actively undertake a project in their local community in which they apply science to tackle a specific problem or to meet a specific need. An example might be on growing a new type of crop to increase the income of the community. Learners explore the long term effects of community projects. For example, a project may have a short term benefit but result in long term detrimental effects

Appendix B: Rogan and Grayson – Profile of Capacity to Support Innovation

Level	Physical resources	Teacher factors	Learners factors	School ecology and management
1	Basic buildings – classrooms and one office, but in poor conditions Toilets available Some textbooks – not enough for all	Teacher is under-qualified for position, but does have a professional qualification	Learners have some proficiency in language of instruction, but several grades below level	***Management*** A timetable, class list and other routine are in evidence The presence of the principal is felt in the school at least half the time, and staff meetings are held at times ***Ecology*** School functions i.e. teaching and learning occur most of the time, albeit erratically School is secure and access is denied to unauthorized personnel
2	Adequate basic buildings in good condition. Suitable furniture – adequate and in good condition. Electricity in at least one room. Textbook for all. Some apparatus for science	Teacher has the minimum qualification for position. Teacher is motivated and diligent. Enjoys hi/her work. Teacher participates in professional development activities Teacher has good relationship with and treatment of learners.	Learners are reasonably proficient in language of instruction. Learners attend school on a regular basis. Learners are well nourished. Learners are given adequate time away from home responsibilities to do school work	***Management*** Teacher attends school/classes regularly Principal is present at school most of the time and is in regular contact with his/her staff. Timetable properly implemented. Extramural activities are organised in such a way that they rarely interfere with scheduled classes. Teachers/learners who shirk their duties or display deviant behaviour are held accountable. ***Ecology*** Responsibility for making the school function is shared by management, teachers and learners to a limited extent. A school governing body is in existence Schools functions all the time i.e. learning and teaching always take place as scheduled.
3	Good buildings, with enough classrooms and a science room. Electricity in all rooms. Textbooks for all pupils and teachers. Sufficient science apparatus. Secure premises. Well kept grounds.	Teacher is qualified for position and has a sound understanding of subject matter. Teacher is an active participant in professional development activities. Conscientious attendance of class by teacher Teachers makes an extra effort to improve teaching	Learners are proficient in language of instruction. Learners have access to quiet, safe place to study. Learners come from a supportive home environment. Learners can afford textbooks and extra lessons Parents show interest in their children's progress	***Management*** Principal takes strong leadership role, is very visible during school hours. Teachers and learners play an active role in school management. ***Ecology*** Everyone in the school is committed to making it work Parents play active role in School Governing Bodies and in supporting the school in general
4	Excellent buildings. One or more well equipped science laboratory. Library or resources centre. Adequate curriculum materials other than textbooks. Good teaching and learning resources e.g. computers, models Attractive grounds. Good copying facilities.	Teacher is over-qualified for position and has an excellent knowledge of content matter. Teacher has extraordinary commitment to teaching. Teacher shows willingness to change, improvise and collaborate and has a vision of innovation. Teachers show local and national leadership in professional development activities.	Learners are fluent in the language on instruction. Learners take responsibility for their own learning. Learners are willing to try new kinds of learning.	***Ecology*** There is a shared vision. The school plans for, supports and monitors change. Collaboration of all stakeholders is encouraged and practiced. ***Management*** There is a visionary, but participatory, leadership at the school

Appendix C: Profile of implementation contextualized for science teaching in Botswana senior secondary schools

Level	Classroom Interaction	Science Practical Work	Science and society
0.5	Context representation • Well organised, correct and we sequenced • Well developed lesson plan • Adequate notes provision • Minimal leaner involvement	• Use of classroom demonstrating to help develop concepts	• Teachers rarely use examples and applications from everyday life to illustrate scientific concepts
1.0	• Notes and textbook effectively used • Engages learners with questions • Learners respond and initiate questions	• Teacher use specimen found in the local environment to illustrate lessons • Engages learners with questions	• Teachers use examples and applications from everyday life to illustrate scientific concepts
1.5	• *Teacher uses textbook along with other resources* • *Uses various teaching methods*	• Teacher uses demonstrations to promote limited form of inquiry	• Learners question about scientific problem or issue faced by local community
2	• Engages learners with questions that encourages in-depth thinking • Learners use additional textbooks sources of information in compiling notes	• Some learners assist in planning and performing the demonstrations	• Lesson based on a specific problem or issue faced by community
2.5	• *Engage in meaningful group work* • *Make own notes on concepts learned from activity* • *Some form of probing of learners' knowledge*	• *Learners participate in closed practical work (cook-book form)* • *Learners communicate data using graphs and tables*	• *Learners through teachers' assistance explore the explanations of scientific phenomena by different cultural groups*
3	• Learners prior knowledge is probed • Learning activities structured along good practice lines: construction of knowledge, knowledge based on problem solving techniques)	• Teacher designs practical work • Practical work design encourages learners' discovery of information • Learners perform guided discovery type practical work	• Learners actively investigate the application of science and technology in their own environment
3.5	• *Introduces learners to the nature of science knowledge* • *Learners engage in minds-on learning activities* • *Make own notes on concepts learned from doing activities* • *Take some responsibility for own learning*	• *Learners write a comprehensive scientific report* • *Learners present findings*	• *Investigations done mainly by means of data getting methods such as surveys*
4	• Major responsibility for own learning by learners • Taking part in planning and assessment of their own learning • Undertake long term and community-based investigative projects • Teacher facilitates, designs and investigations and projects and in theorizing and making explanations	• Learners design and do their own 'open' investigation • Reflect on quality of design, collected data & make improvements • Interpret data in support of competing theories and explanation	• Learners actively undertake a project in their local community in which they apply science to tackle a specific problem or meet a specific need • Learners explore the long term effects of community projects

Appendix D: Profile of capacity to support innovation

	Physical Resources	**Teacher Factors**	• **Learner Factors**	**School Ecology and Management**
0.5	Basic buildings – in poor conditions • Classrooms; one office ; toilet (available) • Textbooks available – not enough	• Teachers under-qualified for positions • Have no professional qualification	• Learners has some proficiency in English but several grades below grade level •	Management: • Timetable, class list and other routines are evident • Presence of principal felt in school most of the time • Staff meeting held at times
1.0	• Furniture available – (bad conditions) • No electricity	• Little motivation to work /teach		Ecology: • *School functions i.e. teaching and learning occur most of the time (erratically)*
1.5	• *Electricity – in at least one classroom*	• *Have professional qualification* • *Poor relationship with other*		• *School is secure and asses is not allowed to unauthorized personnel*
2	• Adequate basic buildings – good conditions • Suitable furniture – adequate and in good condition • Electricity – in at least one classroom	• Teachers have minimum qualification for position • Teacher participant in professional development activities • Good relationship with colleagues	• Learners are reasonable proficient in English language • Attend school on regular basis • Food is provided	• Teacher attends school classes regularly • Principal is present at school most of the times and is in regular contact with staff • Time table properly implemented • Extramural activities organised in a way that they rarely interfere with scheduled classes • Teacher/learner who shirk their duties (or held deviant behavior) are held accountable
2.5	• *Textbook for all – good condition* • *Some apparatus* • *Some laboratory – bad condition*	• *Poor motivation* • *Poor relationship with learners and colleagues* • *Poor teaching experience*	• *Well nourished* • *Learners have adequate time to do school work away from home chores*	• *Responsibility for making school function shared by management, teacher & learners* • *School function all the time* • *Learning and teaching takes place as scheduled*
3	• Good buildings – with enough classrooms • Some science room – good conditions • Electricity in all rooms, running water • Textbooks for all learners and teacher	• Teachers qualified for position • Had sound understanding of SM • Teacher is an active participant in professional development activities • Good attendance by teacher	• Learners are proficient in language of instruction • Have access to quite, safe place to stay, study • Have little supportive home environment	• Principal takes strong leadership role, is very visible during school hours • Teacher & learners play strong active role in school management
3.5	• *Well stocked science laboratories* • *Sufficient science apparatus* • *Well kept grounds* • *One or more well equipped laboratories*	• *Teachers makes extra effort to improve teaching* • *Teacher has good teaching experience*	• *Have support for reading material* • *Have supportive home environment* • *Parents show interest in children's progress*	• *Every one in the school in committed to making it work* • *Parents play active role in school governing bodies and in supporting the school in general*
4	• Excellent buildings: Adequate	• Teacher over-qualified for position • Excellent knowledge of content matter • Show willingness to change; improvise & collaborate • Has vision with innovation • Show local and regional leadership in professional development activities	• Learners are fluent in the language of instructions • Learners take responsibility for own learning • Willing to try new kinds of learning	• There is a visionary but a participatory, leadership at the school • There is a shared vision • School plans for, support and monitors change • Collaboration of all stake holders is encouraged and practiced

Appendix E: Ministry of Education request letter

University of Botswana
Department of Mathematics and Science Education

Private Bag 00702 Gaborone Botswana
Telephone 3552170 * Fax 3185096 * Telex 2429 BD

Ministry of Education
Box 339
Gaborone
Botswana

Subject: Request to conduct a research in Botswana senior secondary schools by Lesego Tawana

Dear Sir/Madam

I am a Motswana student studying for a PhD at the University of Witwatersrand. My area of study is science education, with specific interest in the chemistry education in secondary schools. I wish to apply for permission to conduct my research in Botswana high schools.

My study follows from the newly introduced curriculum in senior secondary schools. Several years now after introduction of the curriculum, I felt it is important to investigate the degree to which senior secondary school teachers are coping with implementation of modern approaches to teaching science in Botswana. The proposed study will attempt an examination of selected schools to find their ability to cope, especially factors having a bearing on chemistry learning. The study hopes to isolate and discuss what appear to be the most important predictors of change, those factors that appear to have been most influential in promoting and encouraging the proposed changes as found in the syllabus and curriculum blue print.

This entails schools' physical resources, ethos and management, teacher and learner factors. Rogan and Grayson (2003) assert that levels of operation can be identified for individual schools and these can then be used to select implementation changes at a level appropriate to a school's level of development in terms of classroom interaction, assessment and science practical. After identifying practices for various schools, recommendation of functional standards will be made to those schools where implementation has been unsatisfactory.

This study will start at the beginning of year 2005 and will involve visits and classroom observation to about six secondary schools in the country. My main focus will be teachers. This should continue until second term.

Hoping my request will be granted

Yours faithfully

Lesego Tawana (Wits University Student)

Appendix F: School request letter

University of Botswana
Department of Mathematics and Science Education

Private Bag 00702 Gaborone Botswana
Telephone 3552170 * Fax 3185096 * Telex 2429 BD

Wits University
P.O Box 003
Wits; 205
South Africa

The Principal
Tagala SSS
Box D11
Tagala
Botswana

Subject: Request to conduct a research in your school

Dear Sir or Madam

My name is Lesego Tawana studying for a PhD in science education at Wits University. I am carrying out research in chemistry education on issues concerning the new curriculum. I would like to request permission to do this research study in your school in the science department with both form 4 and 5 teachers, subject to my obtaining their consent. I would like to observe several chemistry lessons and carry out some interviews with both teachers and learners.

The proposed study follows from introduced BGCSE syllabus. Through observations and interviews to both teachers and learners, the study hopes to discern the school's ability to cope with the changes, especially factors having a bearing on chemistry learning. That is it will try to find the extent to which the various innovations as stressed in the syllabus and the curriculum blueprint are now part of the teachers' understanding and practice. Identifying practices for various schools will help schools see where they are in terms of the purported objectives. This is important since the effectiveness of teachers and the means by which they might be helped to become more effective cannot be answered satisfactorily without the information about the mental life of teachers themselves. Hence, the need to conduct such a study which will hopefully benefit your school.

Hope my request will be accepted

Yours faithfully

Lesego Tawana

Appendix G: Science teacher request letter

University of Botswana
Department of Mathematics and Science Education

Private Bag 00702 Gaborone Botswana
Telephone 3552170 * Fax 3185096 * Telex 2429 BD

June 2004

The Science Teacher
Tagala SSS
P/Bag S20
Tagala; Botswana

My name is Lesego Tawana studying for a PhD in science education at Wits University. I am carrying out a research in chemistry education on issues concerning the new curriculum. I would like to observe several chemistry lessons involving both form 4 and 5 streams and carry out some interviews as well.

The proposed study follows from introduced BGCSE syllabus. Through observations and interviews, the study hopes to discern the school's ability to cope with the changes, especially factors having a bearing on chemistry learning.

- I will therefore need to attend as many of your lessons as possible where I will be making field notes i.e. I will record everything (or almost) that happens in class.
- Sometimes I will tape or video record lesson activities to ensure accurate recording of conversations
- Interviews will be done formally or informally at the end of every lesson.

This is important since the effectiveness of teachers and the means by which they might be helped to become more effective cannot be answered satisfactorily without the information about the mental life of teachers themselves. Hence the need to conduct such a study which will hopefully benefit you and your school. Anonymity of names of schools and all involved subjects will be maintained in all instances.

NB: You can withdraw at any stage of the research study should you feel uncomfortable with the activities or research demands or for whatever reason, without any judgment or penalty. Following the interviews and the tape recordings, I would like to formally request you to give me permission to use the tapes for the purposes of the research study.

If you understand and agree to the process outlined above, will you please sign the information sheet below and it shall be collected from you.

Thank you in advance

Lesego Tawana

Subject: Consent letter

To: Lesego Tawana

I understand the content of this letter: Yes or No

I agree to participate in the study: Yes or No

I agree to let you use the audio and videotapes transcriptions for the purposes of the research study:
Yes or No

Name of Teacher: ----------

Signature: ----------

School: ----------

Appendix H: Checklist for Chemistry Laboratory

The Lab (general impressions): new/old/maintained/ventilation-
Display areas:
Wall space (what is there/how old), bulletin boards, chalkboards
Doors (width, locking)
Projection (method, type, size of screen, distance)
Blackout
Fire fighting, first aid equipment

Teacher's Demo table and fittings: patterns of work in teaching space and services provided:
Brief description of station: size and nature of demonstration area, audio-visual aids, writing facilities

Drawing and the services attached:

Work station/Table and fittings

Item	**Present Type/number**	**Conditions Functionality**	**Accessibility**	**Capacity/ Use**
Brief description of station/working tops/circulation space/cupboards/storage of commonly used apparatus: maximum size of size of audience, range of experimental facilities, audio-visual aids, noise level				

Standard services

Number of stations
Gas outlets
Electricity
Water (hot/cold)
Drainage
Wash up units

Under bench units

Storage cupboards/ Drawers/plastic trays

Other services
Telephone, television, clock, radio, vacuum, compressed air, oven/heaters

Storage facilities: loose/wall cabinets/lockers

Size of the chemistry department/section
Number and size of chemistry groups, number of periods of chemistry in laboratories number of periods of chemistry in lecture rooms, number of periods of chemistry outdoors

Links between branches of science (and connection with other activities)

Physical setting of labs: location, layout, and compartments: Location/presence of exhibition, science library/resource centre, computer facilities, photocopying facilities, photographic darkroom [range of special facilities]

Outdoors special facilities: Large pieces of equipment/use of roof areas

Activities in preparation/store/storage facilities and services
Functions and number of lab technicians/orderly, locations for prep rooms, benches for balances, storerooms, store of dangerous substances

Practical work by students

Size and nature of experiments, space for work in progress, selection of standard apparatus for experiments

Special fittings and services in laboratories
Fume cupboards, ovens

Special apparatus and storage: Balances (electronic), centrifuges, projectors, cameras

Environmental services (Position /rates/ control/intensity/quality)
Heating/cooling, ventilation (noise level), lighting and waste chemical storage…

Appendix I: General-school Schedule

	Present Type/number	**Conditions Functionality**	**Accessibility**	**Capacity/ Use**
1. *School security:* Fencing, security guard: 2. *State of school buildings* Classrooms Furniture Boards Science laboratory Playgrounds Dining facilities Sports facilities Staffroom				
2. *Classroom use;* open all times, activities during Breaks/lessons/after School				
3. Science laboratory uses: Daily use, accessibility supervision				
4. Order/flow of movements to school in the morning, assembly, lessons, meals, sports activities				
5. Assembly supervision, attendance, length, activities & involvement, behaviour, general flow, frequency				
6. Code of conduct (both teachers/students): Dress code, hairstyles- how many breaks the rule; disciplinary/enforcement measures				
7. Special activities' code: sports, physical education lessons				
9. School during & between lessons: order/student (teacher) movements, noise level, principal movements, duration of lessons/breaks; access to toilets				
10. Prefects: Identifiable, respectable, observable duties				
11. General teachers' activities at school				
12. Visit by parents/community: Accessibility				
13. Break/Meal times: student/teacher destinations/activities- supervision/read/prepare				
14. Number of breaks in a day: activities during longer breaks- study/sports/library visits/ computer room visits/access; atmosphere at breaks (busy/relaxed); visits to administration offices, science clinics; afternoon lessons?				
15. Staff meetings: frequency, choice of venue, involvement, atmosphere, staff freedom, and order/flow				

Appendix J: Teacher Interview Questions

How long have you been teaching?
How long have you been teaching chemistry?
What are your teaching subjects?
What is your highest level of qualification?

Curricular activities

1. In your opinion about the new curriculum, what do you think has changed?
2. Has (your) teaching changed? How, can you give some examples?
3. Do you ever have problems with teaching of certain components of the syllabus? Can you give an example?
4. Do you ever have problems interpreting certain content concepts of the syllabus?
   - How about those concepts dealing with structuring learning activities along 'intended practice' lines?
   - Can you give an example?
5. Do you ever have problematic questions coming from students? Can you give an example?
6. Has assessment procedures changed? How has it affected your work?
7. How do you cope with lab demands/arrangements such as preparations for practical and teaching loads?
8. Do you consider your school to have enough provision of resources such as
   - Lab facilities
   - Subject teachers etc

   …required to effect the intended changes?
   If not, what is missing and how would it help?

Professional development/Personal development

9. Do you think there is enough curriculum material support required to effect the intended change (along 'good practice' lines)? Not? What is missing?
10. What level of cooperation or collaboration exists between teachers in you department?
11. Does your school have a working relationship with other schools? What is the nature of cooperation?
12. Are you ever involved in school or regional workshops, conferences?
    - Number of workshops attended/conducted?
    - What is the nature of your involvement?
    - Who decides your involvement?
    - Is there any reporting back to colleagues, department or subject committees?
13. Are you involved in teacher organisations, regional committees? Nature of involvement?
14. Does your school or department have a plan (of action) to support or monitor any intended changes (or innovations). Can you give an example?
15. Does your department have a plan for coming terms or years to do certain things differently? If not how do you track that change is in progress or on course?

Management development

16. How are decisions taken in your department?
17. How much are you involved in departmental issues? [Like allocation of labs, classes, selection for chemistry or streams]. Can you give an example(s) of your involvement?
18. How would you describe your work place?
    - Is there anything (?) that you think hinders you from expression your enthusiasm/affection for the profession? (…In terms of language proficiency, shared vision, staff freedom, physical comfort, involvement offered by the school).
    - How is that a problem/barrier to self-expression…?
19. Does teaching start on the first day of the term to the last day of the term?
    - How would you describe the flow of teaching activities?
    - If not smooth, what stops the flow, timetables, class lists, sports, absence of students and teachers?
20. How would you describe your motivation to work/teach (in this school)?

- Would it be different if you where working in another school/institution or a different job? Why?
- What is holding you here, then?
- What do you want to see change?
- How would it help?

21. How much are teachers involved in the running of the school affairs/meetings?
22. How safe or supportive is the school and home environment for teachers to work?
23. In your opinion what do you think is the level of pupil and teacher involvement and commitment to activities like science clubs, workshops, talks/quiz, and field trips?

- Can you think of an example for both teacher and pupil's case?

24. Do these activities disrupt the flow of teaching activities?
25. What is the level of support (safety) to such activities?

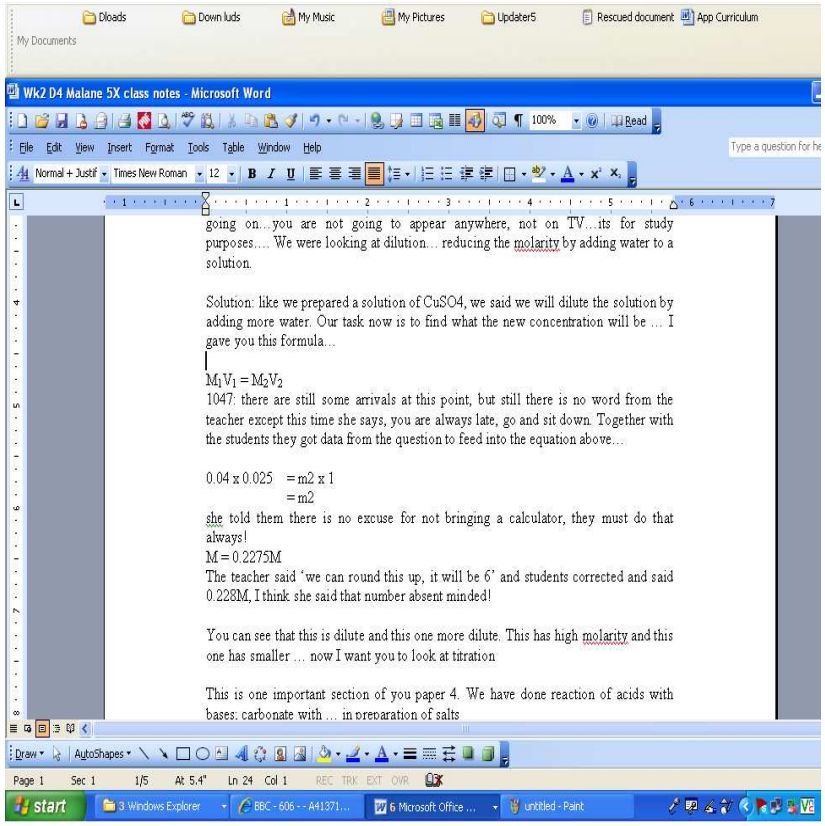
Learner factors

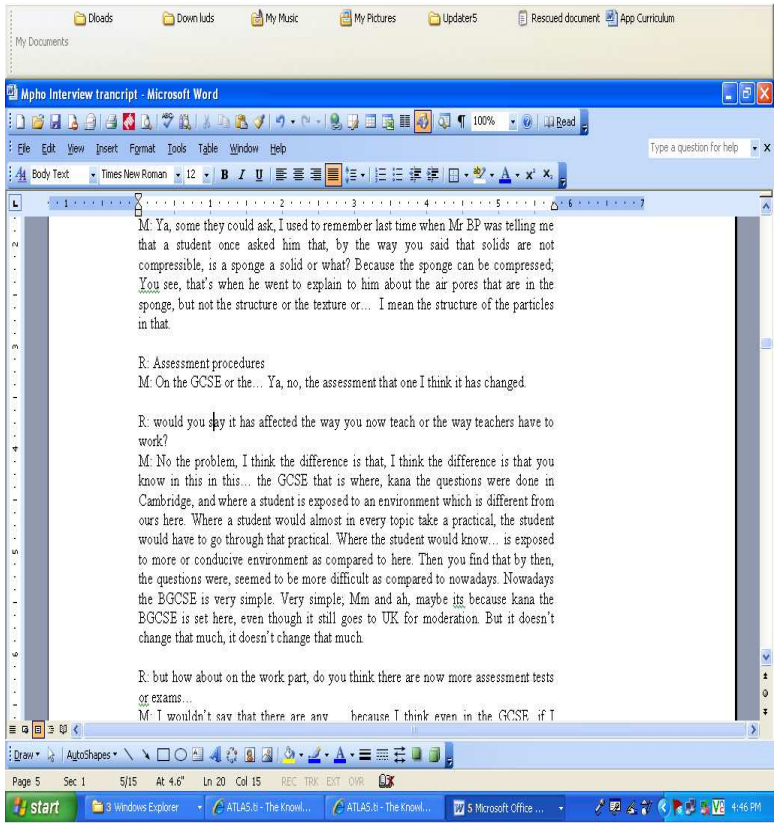
26. What is the general relationship between learners, teachers and management? Can you give an example?

- How much/in what way are students involved in the running of the school?

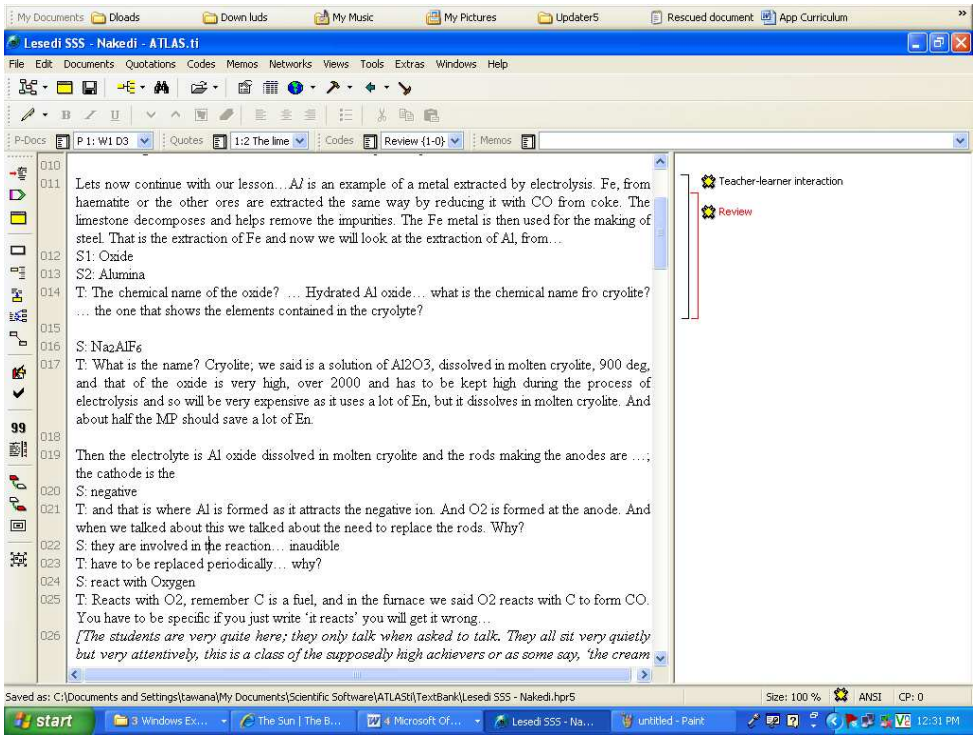
27. How is the language proficiency of learners and teachers in the school? Is it a factor to learning science? How?
28. Are students fed in school? How does this enhance learning activities?
29. How safe or supportive is the school and home environment for students to study?
30. What is the general order, attendance and flow of activities like classes, sports by both learners and teachers?
31. How motivated are learners to study or participate in this school's activities? Why do you think it is so?

Appendix K: Notes from classroom observation and interview transcription

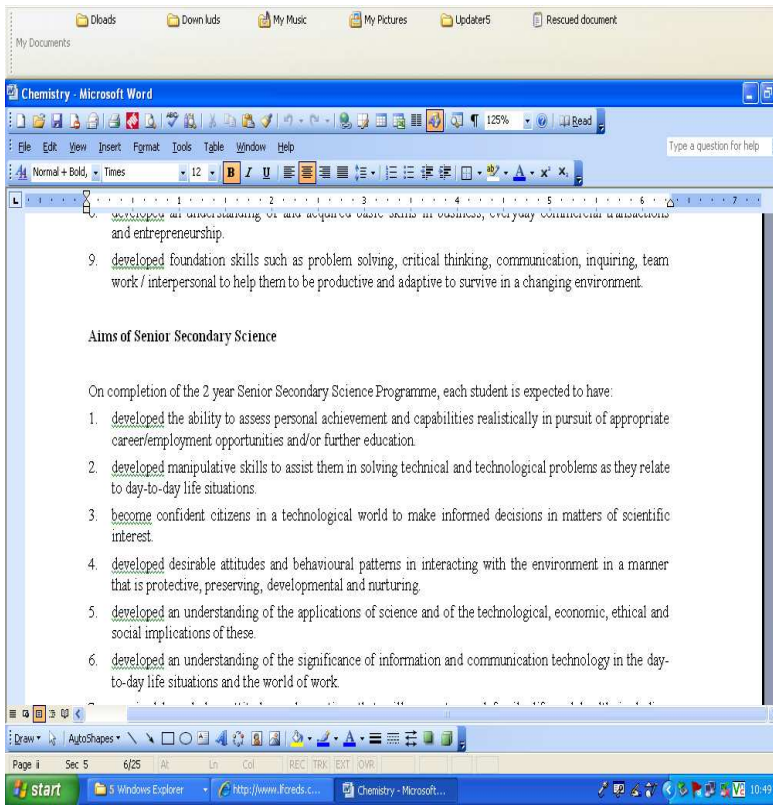




Appendix L: Use of ATLAS.ti



Appendix M: <u>BGCSE chemistry syllabus objectives</u>



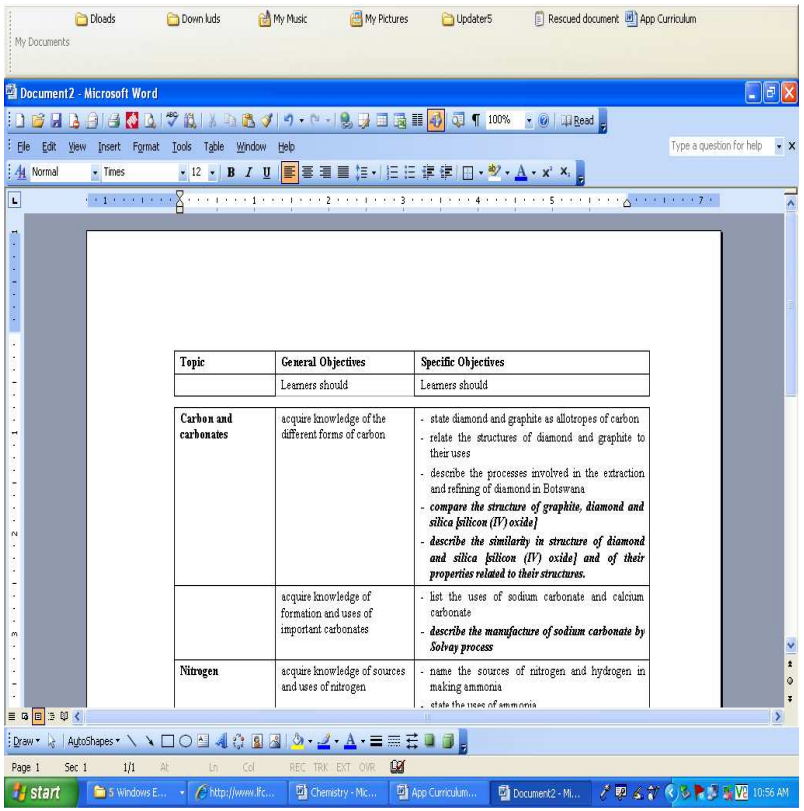
and entrepreneurship.

9. developed foundation skills such as problem solving, critical thinking, communication, inquiring, team work / interpersonal to help them to be productive and adaptive to survive in a changing environment.

Aims of Senior Secondary Science

On completion of the 2 year Senior Secondary Science Programme, each student is expected to have:

1. developed the ability to assess personal achievement and capabilities realistically in pursuit of appropriate career/employment opportunities and/or further education.
2. developed manipulative skills to assist them in solving technical and technological problems as they relate to day-to-day life situations.
3. become confident citizens in a technological world to make informed decisions in matters of scientific interest.
4. developed desirable attitudes and behavioural patterns in interacting with the environment in a manner that is protective, preserving, developmental and nurturing.
5. developed an understanding of the applications of science and of the technological, economic, ethical and social implications of these.
6. developed an understanding of the significance of information and communication technology in the day-to-day life situations and the world of work.



Topic	General Objectives	Specific Objectives
	Learners should	Learners should
Carbon and carbonates	acquire knowledge of the different forms of carbon	- state diamond and graphite as allotropes of carbon - relate the structures of diamond and graphite to their uses - describe the processes involved in the extraction and refining of diamond in Botswana - ***compare the structure of graphite, diamond and silica [silicon (IV) oxide]*** - ***describe the similarity in structure of diamond and silica [silicon (IV) oxide] and of their properties related to their structures.***
	acquire knowledge of formation and uses of important carbonates	- list the uses of sodium carbonate and calcium carbonate - ***describe the manufacture of sodium carbonate by Solvay process***
Nitrogen	acquire knowledge of sources and uses of nitrogen	- name the sources of nitrogen and hydrogen in making ammonia