

**Physical Sciences Teachers' Perspectives and Practices on the
New Curriculum and Assessment Policy Statement**

By

Remeredzayi Gudyanga

Thesis submitted in fulfilment of the requirements for the degree
qualification

Philosophiae Doctor

(Curriculum Studies)

in the

School of Mathematics, Natural Sciences and Technology

Education

Faculty of education

University of the Free State

Bloemfontein, South Africa

June 2017

Supervisor

Professor Loyiso C. Jita

Dedication

I dedicate this thesis to my beloved parents for their support and unwavering (and oftentimes blind) belief in my capacity and ability 'to achieve anything'.

And to my brother, Bookwet Wilson, who has stood by me through the tricky curves I have encountered in this lifetime.

WORDS OF THANKS

I would like to extend my heartfelt gratitude to my supervisor, Professor Loyiso C. Jita, without whose guidance and encouragements this study would have been impossible to complete.

My sincere thanks to all the great colleagues I worked with in the Mangaung schools.

To the SANRAL cohort of 2015, thank you for all we shared during those workshops and presentations. I learnt a lot from all of you during those interactions. And in this group, special mention goes to Dr Comfort Reju, whose motivating spirit was contagious. Many thanks.

Special thanks to Dr Maria Tsakeni and Dr Thuthukile Jita for their reviews and feedback.

My heartfelt thanks to Mr. Richard Alexander and Ms Beverley Wilcock, who edited the chapters of this thesis.

I would like to acknowledge the South African National Roads Agency Limited (SANRAL) for partially sponsoring this study in the form of a bursary through the UFS SANRAL Chair in Science, Mathematics and Technology Education. Thank you.

I also acknowledge the University of the Free State Research Directorate for offering financial support towards this study in the form of a bursary.

DECLARATION OF ORIGINALITY

I, **Remeredzayi Gudyanga (Student Number 2014161596)**, declare that the Doctoral Degree research thesis entitled **Physical Sciences Teachers' Perspectives and Practices on the New Curriculum and Assessment Policy Statement** that I herewith submit for the Doctoral Degree qualification at the University of the Free State, is my own independent work. I further declare that the work has been submitted for the first time at this university and has never been submitted to any other university in part or in its entirety for the purposes of obtaining a degree. All sources I have used or quoted have been acknowledged by means of complete references.

I, Remeredzayi Gudyanga, hereby declare that I am aware that the copyright is vested in the University of the Free State.

I, Remeredzayi Gudyanga, hereby declare that all royalties as regards intellectual property that was developed during the course of/or in connection with the study at the University of Free State, will accrue to the university

SIGNATURE OF STUDENT.....

DATE.....

ABSTRACT

Previous reform efforts in the South African school system have been confronted with challenges during the implementation stages where teachers are acknowledged as central agents. A scarcity of comprehensive studies on physical sciences teachers' perspectives and concerns exists and the manner in which these influences their practices during the current Curriculum and Assessment Policy Statements (CAPS) reforms. The main research question for this study is *what are physical sciences teachers' perspectives, concerns and practices on the CAPS in the Motheo District of South Africa?* To respond to the research question and the sub-questions, a sequential explanatory mixed methods approach, consisting of a stage of concern and open-ended questionnaires, observations, document analysis and semi-structured interviews was employed. Quantitative data were analysed using the Statistical Package for Social Sciences (SPSS) and interviews were transcribed, coded into themes and then categorised. There are several significant findings stemming from this study. Most teachers seemed more concerned about challenges experienced during the previous National Curriculum Statement curriculum (NCS) such as time constraints, insufficient content knowledge, insufficient practical skills and large workloads. Receptivity to change was largely due to expectations that CAPS would resolve these challenges (innovation expectations) rather than their actual experience with the CAPS curriculum (innovation experiences). When the innovation does not live up to their expectations, teachers may become indifferent towards the innovation. Most (92%) of the 81 participants taught chemistry and physics topics, though a significant number of them (36%) had only majored in one of these subjects. In times of curriculum reforms, existing teachers' deficiencies in content knowledge and practical work are magnified when teachers have not majored in chemistry and physics. To cope with these challenges, participants in this study had devised different strategies, including using a variety of support materials and teacher-centred approaches. Despite these coping mechanisms, this study concludes that CAPS reforms might not have significantly changed teachers' practices. This study recommends the re-training of physical sciences teachers in conducting experiments and regular workshops aimed at enhancing their content knowledge. The separation of physical sciences into chemistry and physics, and the introduction of trained laboratory assistants could be considered in the next curriculum change cycle.

TABLE OF CONTENTS

Dedication	i
WORDS OF THANKS	ii
DECLARATION OF ORIGINALITY	iii
ABSTRACT	iv
TABLE OF CONTENTS	v
LIST OF TABLES	viii
LIST OF FIGURES	ix
LIST OF APPENDICES	x
Chapter One: Orientation of the study	1
1.1 Introduction	1
1.2 Background to the problem	2
1.3 Rationale of the study	5
1.4 Research problem	6
1.5 Conceptual and theoretical framework	9
1.6 Research methodology	10
1.7 Quality measures and ethical considerations	12
1.8 Limitations of the study	12
1.9 Definition of terms	13
1.10 Outline of chapters	14
1.11 Summary of chapter one	14
Chapter Two: A review of pertinent literature	15
2.1 Introduction	15
2.2 Curriculum implementation research	15
2.3 The topology of curriculum representations during implementation	19
2.4 The concerns-based adoption model: The conceptual framework	23

2.5	Teachers' perspectives during reforms	28
2.6	Fidelity of curriculum implementation	30
2.7	Implementation integrity and actor-oriented perspectives	31
2.8	Curriculum changes in post-1994 South Africa	32
2.9	Curriculum and Assessment Policy Statements (CAPS)	38
2.10	Teachers' perspectives during science curriculum reforms	48
2.11	Research perspectives on CAPS implementation	51
2.12	Pertinent curriculum implementation research and CBAM	55
2.13	Processing SoCQ data	57
2.14	Conclusions	59
Chapter Three: Research methodology		60
3.1	Introduction	60
3.2	Research paradigm	62
3.3	Sub-research questions alignment with methodological approaches	71
3.4	Sampling procedures	74
3.5	Pilot study	76
3.6	Data collection: Methods and procedures	77
3.7	Data documentation	85
3.8	Data analysis	86
3.9	Trustworthiness of the study	88
3.10	Ethical issues	94
3.11	Conclusions	95
Chapter four: Findings of the study: Analysis and discussions		96
4.1	Introduction	96
4.2	Demographic data of the participants	96
4.3	Presentation and discussion of stages of concern results	98
4.4	Qualitative Phase: Analysis and Discussion of results	105

4.5	Document analysis: Results and discussion	141
4.6	Motheo district physical science teachers' perspectives about CAPS	142
4.7	Physical sciences teachers' practices on the new CAPS	149
4.8	Integration and synthesis of results from the study	162
4.9	Chapter four summary	167
	Chapter five: Discussion of findings and conclusions	168
5.1	Introduction	168
5.2	Overall summary of the research	168
5.3	Key findings and their significance	170
5.4	Recommendations on improving CAPS implementation	178
5.5	Implications for practice, policy and further research	181
5.6	Limitations of the study	184
5.7	Conclusions	184
References	189	
Appendices	209	

LIST OF TABLES

Table 2.1: Curriculum representations by Van den Akker <i>et al.</i> (2008: 6)	19
Table 2.2: Curriculum levels and descriptions (Thijs & Van den Akker, 2009)	20
Table 2.3: Perspectives on curriculum (Goodlad, 1994).....	22
Table 2.4: NCS weighting of cognitive levels (DBE, 2011: 143)	44
Table 2.5: CAPS weighting of cognitive (DBE, 2011: 144)	44
Table 3.1: An outline of the research methodology and design	61
Table 3.2: Criteria framework by Onwuegbuzie and Comb (2010).....	69
Table 3.3: Alignment of sub-research questions with methodological approaches	73
Table 3.5 Examples of stages of concern typical questions	79
Table 3.6: Internal reliability ratings of the SoCQ (George <i>et al.</i> , 2013:20)	89
Table 3.7: Test-retest correlations on the SoCQ (George <i>et al.</i> , 2013: 20)	90
Table 3.8: Cronbach's alpha if item is deleted.....	90
Table 4.1: Summary of demographic data of participants	96
Table 4.2: Summary of emerging themes.....	107
Table 4.3: Revision: Comparing and contrasting of Acids and bases.....	109
Table 5.1: Sub-research questions and the corresponding instruments.....	169

LIST OF FIGURES

Fig. 3.1	Map of the Free State (http://www.businessinsa.com/).....	74
Fig. 4.1	Relative intensity of Stages of Concern of the whole cohort.....	99
Fig. 4.2	Stages of concern raw scores vs educational qualification.....	102
Fig. 4.3	Stages of concern raw scores vs years of teaching experience	103
Fig. 4.4	Andre's individual relative intensity profile	108
Fig. 4.5	Sub-microscopic representation of strong acid dissociation	112
Fig. 4.6	Sub-microscopic representation of weak acid dissociation.....	112
Fig. 4.7	Karabo's individual relative intensity profile.....	117
Fig. 4.8	Thandie's individual relative intensity profile.....	124
Fig. 4.9	Diagrammatic representation of Photon Absorption and Emission.....	125
Fig. 4.10	Siyanda's individual relative intensity profile.....	129
Fig. 4.11	Thabo's Individual relative intensity profile.....	137

LIST OF APPENDICES

Appendix A1	Ethical Clearance (UFSHSD2015/0632)
Appendix A2	Permission from the Free State Department of Education
Appendix A3	Notification of Permission from Provincial office to District office
Appendix B1	Letter to School Principals
Appendix B2	Letter of informed consent to physical sciences Teacher
Appendix C1	Stages of Concern SEDL permission
Appendix C2	Stages of Concern Questionnaire
Appendix C3	Scoring device for Stages of Concern
Appendix C4	Stages of Concern Percentile Conversion chart
Appendix D	Observation protocol
Appendix E	Document Analysis Guide
Appendix F	Semi-structured interview schedule for physical sciences Teachers
Appendix G	Grade 11 work schedule term 3
Appendix H	Grade 12 work schedule term 2
Appendix I	Examinable Content Grade 12 Acids and Bases
Appendix J	Andres Practical class: Titration
Appendix K	Appendix K: Karabo's Homework Question
Appendix L	Karabo's Classwork Question
Appendix M	Karabo's Practical class: esterification

Chapter One: Orientation of the study

1.1 Introduction

Since 1994, the South African Department of Basic Education (DBE) has introduced several reforms to alter classroom practices and improve the teaching and learning process in subjects such as physical sciences. First, Curriculum 2005 (C2005) was introduced, which was followed by the National Curriculum Statement (NCS). The Curriculum and Assessment Policy Statement (CAPS) has recently been introduced. Curriculum implementation is known as quite a complex and difficult process (Holloway, 2003; Spillane, Reiser & Reimer, 2002), and often the proposed curriculum innovations do not produce the desired results (Christou, Eliophotou-Menon & Phillippou, 2004; Spillane *et al.*, 2002). Some of the challenges in curriculum reform implementation revolve around the nature of the curriculum documents used to drive the reform, teachers' inadequate content knowledge and the gap between current practices and the suggested practices of the new curriculum (Spillane *et al.*, 2002). Other challenges revolve around teachers' inability to make appropriate sense of the reforms, not addressing teachers' concerns, teachers' understanding of the new curriculum and time restrictions (Bennie & Newstead, 1999). Some experts are of the opinion that C2005 failed because it was idealistic and overly ambitious, especially considering the economic and political climate of the time (Taylor, Muller & Vinjevd, 2003). Other researchers (Jansen, 1998; Rogan & Grayson, 2003) attribute the failure to an emphasis on the "what" rather than on the "how" of the reform programmes. As per departmental reports (DBE, 2011), revision of C2005 came about because of the challenges faced during its implementation. Furthermore, challenges in the implementation of the NCS resulted in another review in 2009, which gave rise to the new CAPS. Recent departmental documents confirm that the reason for the introduction of the new CAPS reform is a failure in implementing the NCS (DBE, 2011).

Jansen (1998) makes a strong appeal for the need of a holistic approach to overhaul the whole education system for real change to take place. Research by Rogan and Grayson (2003) is significant in this regard in that they attempt to develop a theory of curriculum implementation in the South African context. However, despite such significant contributions to the curriculum implementation literature, there are still knowledge gaps pertaining to teachers' concerns and their significance in the success

(or failure) of curriculum implementation. An in-depth consideration of teachers' perspectives, concerns and practices in specific subject areas may broaden the knowledge and assist in informing the present and future implementation of curricula in South Africa and elsewhere. According to Jita and Mokhele (2013), teachers do not simply implement the curriculum (policies) without trying to make their own sense and meaning of national curriculum guidelines.

This study explored physical sciences teachers' perspectives and practices regarding the implementation of the new CAPS curriculum. Principals, heads of departments and teachers confront any sort of reforms with their personal set of concerns and prior experiences (Holloway, 2003; Spillane, 1999). Assisting these stakeholders to deal with their concerns and to align the reform ideas with what they already know from their experiences is critical if the implementation is to be successful and achieve the desired results. Research has shown that in terms of innovations and reforms, teachers may regard themselves as either qualified or unqualified to implement the suggested new reforms (Holloway, 2003; Spillane, 1999). It is common for reforms and innovations to fall behind scheduled timeframes envisaged by policymakers and reformists, in part because of the implementation challenges related to the implementers' (or teachers') sense-making processes (Thompson, 1992). Some teachers may resist change if they are not convinced that the reforms will benefit their students or that the innovations will make it easy for them to do their job (Thompson, 1992). However, as Sternhouse (1983) argues, with the earlier reforms of the 1960s and 70s, the major problem was not so much resistance to change as it was about the barriers that teachers encountered in trying to change their practices. If such barriers are to be removed, then it becomes logical to attempt to understand teachers' concerns and understandings of the reforms to overcome any of those barriers that teachers encounter in their attempts to change their practices.

1.2 Background to the problem

The South Africa Department of Basic Education (DBE) has recently initiated several reforms, from C2005 to the NCS and most recently CAPS. Whereas the main objective of introducing C2005 was in an attempt to bridge the disparity gap in the distribution of resources brought about by the apartheid system, the NCS sought to emphasise

the need for learners to become critical thinkers and problem solvers. Teachers were required to shift their practices from a content-driven and teacher-centred traditional approach to a learner-centred approach. However, the success of any programme depends on the implementation process.

Clarity on how the new CAPS curriculum is different from the old NCS curriculum would be an important initial step for educators if they were to be effective agents of change. Sternhouse (1983) observed that a lack of clarity regarding new reform ideas is one of the barriers to change in teacher practice, despite their best efforts to accept education innovations. Whether the CAPS curriculum is a new curriculum altogether or simply a rearrangement of the NCS documents so that the latter becomes easier to implement continues to be the subject of debate.

According to the DBE, CAPS is a document in which curriculum documents have been reorganised in such a way that they will enhance the implementation of the NCS by teachers (DBE, 2011). After consultations, government and policymakers conceded that implementation challenges were the major reasons for the revision of both versions of the curriculum reforms – the NCS and CAPS – in the country (DBE, 2011). Surveys and consultations suggest that teachers faced different challenges, which ultimately became barriers that made it difficult for them to implement the necessary changes in classrooms (DBE, 2011). Thus, departmental documents categorically state that the main reason for CAPS is to improve implementation.

In the new CAPS, learning areas are now referred to as subjects, and there is reduced paperwork with which teachers need to deal (DBE, 2011). Terms such as learning outcomes and assessment standards have been replaced with specific content skills to be achieved in the form of knowledge and skills. In physical sciences, there have also been substantial changes in content with the addition of sub-topics such as the Big Bang theory under the Doppler Effect. In organic physical sciences, there has been, among other changes, the addition of a section on polymers, including types of polymers and ways in which to distinguish between addition and condensation polymerisation.

However, some of the biggest changes have been in the way the assessment questions are framed in the final examinations in grade 12. In the CAPS curriculum, for instance, many of the questions do not provide hints to the learners, as was previously the case under the NCS. For example, the NCS question would be phrased as follows: "Using energy, intermolecular forces and structure explain why molecule A has a higher boiling point than molecule B". In CAPS, the question would be phrased along these lines: "Explain why molecule A has a higher boiling point than molecule B using physical sciences principles". Thus, the CAPS assessment requires learners to understand the science instead of depending on hints in the examination to answer questions successfully. There has also been a change in the cognitive level demand on the learners (DBE, 2011).

My initial analysis, as in the discussion above, suggests that CAPS goes beyond a simple reorganisation of documents. Some academics dispute the official position taken by the Department of Basic Education that the CAPS curriculum is simply the old NCS save for documental reorganisation (Nakedi *et al.*, 2012). Citing significant changes in the content, adjustments in the assessment of the cognitive levels in the final examinations as well as the wording in the questions, Nakedi *et al.* (2012) consider CAPS a new curriculum, at least in physical sciences. The fact that these changes in curriculum are on different levels (change in cognitive levels, assessment strategies, content depth and breath, time allocations) provide some of their evidence. At each level, teachers should first be able to evaluate themselves in terms of their shortcomings and what they think they need to do (or what needs to be done) to implement the new reforms with the fewest possible challenges. The departmental position on whether CAPS is a new curriculum altogether seemingly contradicts some researchers' views. This has also led to some confusion among stakeholders. Teachers need a clear understanding of any reforms if they are to implement them successfully.

For reforms to be implemented successfully, as envisaged by policymakers, physical sciences teachers need to feel recognised as the ultimate agents of change without whose cooperation the reform efforts are unlikely to be successful. This study seeks to explore physical sciences teachers' perspectives, concerns and practices during the current implementation process of the CAPS reform. When their concerns,

practices and perspectives are understood, strategies can be developed to ease the challenges of implementation.

1.3 Rationale of the study

This study stems from my experiences as a physical sciences teacher and laboratory instructor in different countries, namely Zimbabwe, Cuba, Namibia, the United States and South Africa. In all these countries, education reform, especially science education, has been highly prioritised. Reform programmes, however ambitious, are always subject to a multitude of implementation challenges and are seldom implemented as planned by teachers in schools (Creswell, 2013). In recent times, South Africa has seen different curricula being proposed and implemented, from C2005, to the revised NCS and presently CAPS.

According to the Department of Basic Education, there is consensus that the main challenges faced by the department in terms of curriculum are problems of implementation (DBE, 2011). This has been confirmed by other studies that cite the “confusion created by document proliferation” as one reason teachers found NCS difficult to implement (Nakedi *et al.*, 2012:285). Nakedi *et al.* also cite the lack of congruency between curriculum content and examination questions in the final grade 12 examinations as another reason leading to the failure and subsequent discontinuation of NCS. Reform programmes are only as good as the implementation process. It serves little purpose to have an excellent programme, if the implementation process is not well planned. A good foundational understanding of the challenges, efficiencies and effectiveness of curriculum reform implementation is necessary to inform the present and future implementation of the reforms.

If more research efforts are directed at the implementation process, a significant portion of those studies should focus on how teachers react to curriculum reforms (Christou *et al.*, 2004). Research findings by Manouchehri and Goodman (2000) challenge the perceived notion that teachers can change their practices by simply putting innovative materials in their hands. Teachers need concrete images that guide them to ideas about what it is like to practise teaching in ways that are consistent with the reform efforts (Manouchehri & Goodman, 2000:159). An initial stage to be

included, before these strategies and other forms of support are provided to teachers, would be to explore the types of concerns, feelings and perceptions teachers have regarding the reform itself.

As a teacher, I have experienced some of the emotions associated with curriculum reforms: frustration, a sense of helplessness and a sense of disconnection from the reforms that I am being asked to implement without question. My voice and concerns have not been heard. I have often felt the need to take part in the change but had no idea where to start. Sometimes I found myself lacking the resources needed to implement the change successfully into practice. I have even observed colleagues, who seemed to see no need for change and go about their day-to-day business as usual. Yet, in any reform, teachers are recognised as the agents of change whose cooperation and willingness to implement the innovations are critical for the changes to succeed.

Some of these experiences have motivated me to conduct this research on the physical sciences teachers' concerns with the implementation of the CAPS reform in South Africa.

1.4 Research problem

The literature reviewed thus far seems to suggest that the implementation process of CAPS in the physical sciences is fraught with obstacles that may result in the failure of the reform to take root. Some of these obstacles stem from a lack of knowledge and understanding of the teachers' potential concerns, perspectives, and practices during the implementation process. Teachers' perceptions, concerns and perspectives should be explored during the implementation of curriculum innovation as one way of seeking to increase the chances of successful implementation.

1.4.1 Research questions

Against this background, the following main research question is proposed: What are physical sciences teachers' perspectives, concerns and practices on the new Curriculum and Assessment Policy Statements in the Motheo District of the Free State province of South Africa?

The main research question was explored by answering the following sub-questions:

1. What perspectives do physical sciences teachers have about the changes from NCS to CAPS?
2. What are the common concerns that practising physical sciences teachers have about the implementation of the new CAPS curriculum?
3. What are the relationships, if any, between physical sciences teachers' stages of concern and their level of education?
4. What are the relationships, if any, between physical sciences teachers' stages of concern and their years of experience?
5. How can physical sciences teachers' practices on some of the new CAPS topics or new sub-topics be described?
6. How do physical sciences teachers' perspectives and concerns influence their classroom practices on some of the new CAPS topics or sub-topics?

1.4.2 Hypotheses

The first phase of this study is quantitative and seeks to answer the following questions and test the corresponding hypotheses.

Question 3: What relationships exist between physical sciences teachers' stages of concern regarding the CAPS curriculum and their level of education?

Hypothesis: There is no correlation between raw scores of each of the stages of concern and the physical sciences teachers' level of education.

Independent variable: level of education (qualifications)

Dependent variables: stages of concern raw score

Question 4: What relationships exist between teachers' stages of concern and their years of teaching (or experience)?

Hypothesis: There is no correlation between raw scores of each of the stages of concern based on the physical sciences teachers' years of teaching (or experience)

Independent variable: years of teaching (or experience)

Dependent variables: stages of concern raw score

1.4.3 Aim and objectives

The aim of this research is to describe physical sciences teachers' concerns, perspectives and practices during the implementation process of the new CAPS.

The research seeks to meet the following objectives:

- to determine physical sciences teachers' perspectives regarding the new CAPS curriculum
- to document the common concerns faced by physical sciences teachers in the CAPS implementation process
- to establish the relations between physical sciences teachers' stages of concern and their level of education
- to establish the relations between teachers' stages of concern and their years of experience
- to describe physical sciences teachers' practices on some of the new topics or sub-topics of the CAPS curriculum
- to explain the influence of teachers' perspectives and concerns on their classroom practices on some of the new topics or sub-topics of the CAPS curriculum.

1.4.4 Value of the research

Curriculum implementation has been known to be a difficult process (Spillane *et al.* 2002) and when it is not managed or assessed properly, it may lead to confusion in the teaching and learning process. In some cases, teachers have been known to continue doing things the same way as before. There is a need to close the gap between what teachers understand and what the reformers have in mind. Isolated workshops cannot fully bridge this gap, and the traditional "one workshop" approaches to professional development have been inadequate and inappropriate in addressing

the developmental needs of teachers (Dass, 1999; Mokiwa, 2014). More prolonged and intensive professional development programmes are more likely to meet teacher needs (Kriek & Grayson, 2009). It is thus important to understand how teachers, as the implementing agents, interpret, understand and think about the new curriculum during the early implementation stages.

This research sheds light on how teachers are implementing the new CAPS curriculum. It unpacks what challenges they face and seeks to provide recommendations on how to ease these challenges. In effect, the findings from the study seek to bridge the gap between teachers' perspectives, understandings and practices and the aims and objectives that policymakers have for the new CAPS.

The study also seeks to expand the knowledge horizons of mixed methods research as a research approach in a field that has been dominated by an either-or attitude where researchers use either a qualitative or a quantitative approach. This is especially true in the context of science education research in South Africa. This study may further assist in strengthening the case for the utilisation of mixed methods research in comprehending complex social problems where either a quantitative or a qualitative approach alone may fail to provide a complete understanding and/or explanations.

1.5 Conceptual and theoretical framework

The concerns-based adoption model (CBAM), developed by Hall and Hord at the University of Texas in 1973 (Christou *et al.*, 2004), frames this study. In recent decades, some research findings have confirmed the correlation between individual teachers' concerns and perspectives, and the successful implementation of reforms and innovations in education (George *et al.*, 2013). Addressing teachers' concerns can assist in developing continuous support programmes that assist teachers during the implementation process (Hall & Hord, 2015; Holloway, 2003). Concerns can be described as reactions, thoughts and feelings that teachers develop regarding curriculum changes (Hord *et al.* 1998). Fuller (1969) categorises teachers' concerns into three groups: impact, self and task concerns. Impact concerns are about teachers' worries pertaining to students' outcomes, self-concerns involve the ability of students

to perform in the school environment and task concerns relate to obstacles in the teachers' daily duties such as the lack of resources and large classroom sizes. Fuller's framework thus lays the foundation for studies on teachers' concerns regarding educational innovations and reforms (Christou *et al.*, 2003). Although Fuller initiated research on teachers' concerns in the late 1960s, Hall and Hord developed CBAM as a research-based framework and methodology in 1973. This model was developed for the evaluation, description, measurement and explanation of various aspects of reform that teachers implement (Holloway, 2003). CBAM describes how individuals evolve as they learn about the reforms and the stages of the reform process (Holloway, 2003). According to Hall and Hord (2015), CBAM is a set of tools that enables the understanding and management of change in agents of change, such as teachers. CBAM has become a credible change model used by a wide range of individuals planning for staff development in times of reform implementations (Hall & Hord, 2015).

CBAM is based on five assumptions as outlined by Hall & Hord (2015). Firstly, change should be a process. Secondly, change is individual. Thirdly, the perceptions and feelings of individuals are critical for successful reform. Fourthly, individuals go through different stages in how they feel about reforms and in their capacity and ability to align their practice with those reforms. Finally, policymakers and those enforcing reforms must proceed systemically, assess periodically and aid continually (Hall & Hord, 2015). The broad argument of CBAM is that if those in charge of policy and policy reforms are to assist the on-site agents of implementation – in this case teachers – then they must be aware of the concerns that teachers harbour. Successful implementation of any curriculum innovation therefore depends on how the concerns of teachers, as key implementers, are addressed.

1.6 Research methodology

The worldview that guides this study is pragmatism. Pragmatism, as a research worldview, emerged in the 1990s through research carried out by Pierce, Dewey and others (Cherryholmes, 1992). In recent times, some researchers (Cherryholmes, 1992; Murphy, 1990; Patton, 2002; Rorty, 2000) have made significant contributions in presenting the case for pragmatism as a recognised, useful worldview. Pragmatists posit that knowledge claims arise from actions, situations and consequences rather

than from some predetermined conditions. They tend to emphasise “what works” and therefore attach greater importance on the problem than on methods. For pragmatists, all approaches or methods are possible options in solving and understanding a problem (Rossmann & Wilson, 1995). Thus, in this study, the mixed methods approach is considered appropriate for exploring teachers’ perceptions, concerns and practices related to CAPS. The appeal to mixed methods researchers is that I can draw liberally from qualitative and quantitative approaches to address the research problem.

The type of mixed method used in this study is called the sequential explanatory strategy (SES). In SES, one dataset builds on the results from the others. This study therefore consists of two phases: a post-positivist initial phase where data is collected using one of the CBAM instruments, the stages of concern (SoC) questionnaire, followed by an interpretive qualitative phase in which interviews and observations are used. In this strategy, quantitative data were collected and analysed first, followed by the collection and analysis of qualitative data (Terrell, 2011). The interpretive, qualitative second phase builds on the results from the initial post-positivist quantitative phase. The findings from the qualitative and quantitative phases are integrated during the interpretation stage. The purpose of this mixed methods study is complementarity, in which findings from the qualitative phase are used to elaborate, illustrate, enhance and clarify the findings from the initial quantitative phase (Combs & Onwuegbuzie, 2010). The quantitative data seek to respond to some of the sub-research questions, such as questions two, question three and question four (cf. section 1.3), which probe the “what” of teachers’ concerns and perspectives in CAPS implementation. To shed more light on findings from the quantitative phase, a qualitative phase follows. Classroom observations, document analysis and semi-structured interviews were conducted. The participants for these methods of data collection were purposively selected from the original sample to respond in part or entirely to the following sub-research questions:

- What perspectives do physical sciences teachers have about the changes in the CAPS?
- How can physical sciences teachers’ classroom practices on the new CAPS topics or sub-topics be described?

- How do physical sciences teachers' concerns and perspectives explain some of the classroom practices on some of the new CAPS topics or sub-topics?

Thus, to respond to all the sub-research questions in this study satisfactorily required using a mix of quantitative and qualitative methods. The advantages of SES are that it is a straightforward strategy with clear distinctions between stages.

1.7 Quality measures and ethical considerations

Procedures to obtain ethical clearance were followed and the responsible University of Free State authorities granted the clearance. Consent was sought and the Free State Department of Basic Education granted ethical clearance to conduct this study. Consent was sought from participants and issues of confidentiality were discussed. The first quantitative phase for this study involved collecting data using the stages of concern (SoC) questionnaire survey in the Motheo District of South Africa. Permission to use the instrument was sought and granted. Partial analysis of the quantitative data led to purposive sampling of five individuals from the original sample for class observations, document analysis and interviews. This formed the qualitative phase. Data from the quantitative and qualitative phases were analysed and integrated. To enhance trustworthiness, details on objectivity, internal validity, external validity and reliability during the quantitative phase have been reported. I also discussed the qualitative equivalent constructs of trustworthiness such as credibility, transferability, dependability and confirmability.

1.8 Limitations of the study

Although this study provides significant insight into teachers' perspectives, concerns and practices in physical sciences during the implementation of CAPS, certain limitations are inevitable. This study was carried out with participants in the same district. There may be discrepancies among districts, which may limit the generalisation of the findings in the entire province or to the whole country. Surveys are also limited to only what the researcher seeks to understand and to what the researcher gives priority. However, throughout the study I have made efforts to mitigate the effect of these limitations. Firstly, to reduce the limitations of the survey, numerous methods of data collection have been used in this study. Data collected

using questionnaire surveys, in addition to their subsequent analysis, were used to construct assumptions and these initial findings were not considered as final truths. These preliminary findings were further explored through observations, interviews, and document analysis in this mixed methods study. Secondly, to increase the generalisability of the findings, a wide variety of schools and participants were selected from the Motheo District including rural, former Model C, township schools and teachers in a way that is representative of the South African landscape. However, the generalisability of the findings of this study was not a top priority; any similar studies in different contexts would contribute to give a better picture of physical sciences teachers' perspectives and practices during times of curriculum reforms.

1.9 Definition of terms

Concerns: Refers to “the composite representation of the feelings, preoccupations, thoughts, and considerations given to a particular issue or task” (Hall & Hord, 1987: 138).

Dynamics: the issues and tensions, the factors that hinder or help; the constraints, possibilities or difficulties of policy implementation (Hunter & Marks, 2002).

Practical work: practical demonstrations, experiments or projects used to strengthen the concepts being taught.

Implementation: is the process of enacting planned curriculum and the translation of a written curriculum into classroom practice (Marsh & Willis, 2003:214).

Concerns-based adoption model (CBAM): is a model that tracks and assesses innovation implementation.

Curriculum: Curriculum is all the experiences learners have under the guidance of the school (Marsh & Willis, 2003).

Teacher practices: The way teachers conduct their core business of lesson planning, lesson delivery and assessment. When used in the context of classroom instruction, it refers to the way teachers ask questions, how much waiting time they allow for the learners to respond, whether they are learner-centred or teacher-centred and how they deal with students' zones of development.

Perspectives: is a point of view or way of regarding something or (Colman, 2015).

1.10 Outline of chapters

1.10.1 Chapter One: Orientation of the study

In Chapter one, I describe the problem addressed by this study and its purpose. I give a brief background of curriculum implementation research followed by the problem statement.

1.10.2 Chapter Two: Literature review

Chapter two focuses on the current literature on curriculum reform implementation in education. I discuss different perspectives and theories on reform and innovation implementation from local and international perspectives.

1.10.3 Chapter Three: Research design and methodology

In Chapter three, I provide an outline of the empirical methods that were used to carry out this research. The theoretical framework and conceptual framework that form the basis of this research are presented.

1.10.4 Chapter Four: Findings of the study: Analysis and discussions

In this chapter, I give descriptions of the research findings on teachers' perceptions and concerns regarding current reform efforts in the Free State, South Africa. The chapter includes the data analysis and interpretation from the two phases of the study.

1.10.5 Chapter Five: Discussion of the findings and conclusions

In this chapter, I present my findings in the context of what already exists in the literature and how my findings differ from the existing literature. This chapter concludes the study by summarising the research and stating its contributions towards extending knowledge horizons.

1.11 Summary of chapter one

Chapter one contained a description of the problem addressed by this study and of the study's purpose. I gave a brief background of curriculum implementation research followed by a statement of the problem. The research problems, research aims and objectives were stated. I also briefly presented the theoretical framework and the philosophical underpinnings that guide the study. In chapter two, I discuss the literature review.

Chapter Two: A review of pertinent literature

2.1 Introduction

This chapter explores literature pertinent to teachers' perspectives and practices during curriculum reform implementation from international and national perspectives. A brief history of curriculum changes in post-1994 South Africa is also discussed including challenges and dynamics of the previous experiences during the implementation of Curriculum 2005 and the previous National Curriculum Statements (NCS). The teachers' central roles as agents of change during curriculum implementation are also explored. The complex nature of individuals' sense making process is discussed and arguments are presented on why teachers' perspectives, concerns and practices should be investigated. The chapter reports, critically examines and evaluates claims and methodological approaches used in recent studies. Knowledge gaps are identified and areas for further research to expand knowledge horizons in curriculum implementation are suggested.

2.2 Curriculum implementation research

The gap between what the designers of reform programmes intended and how teachers make sense of these programmes has long been of concern to researchers (Brown & Campione, 1996; Brown & Edelson, 2001; Cordray & Pion, 2006; Cuban, 1998; Fullan, 1993; Lopez & Wise, 2015; Sarason, 1990; Spillane, 1999). In the 1970s, some leading researchers noted that, "...the bridge between a promising idea and the impact on students is implementation, but innovations are seldom implemented as intended..." (Berman & McLaughlin, 1976: 349). This discrepancy became known as the "implementation gap" and since then curriculum implementation has developed into an independent research field that focuses on solving the problem of persistent failure of educational reform and on bridging the "implementation gap" (Cuban, 1998; Fullan, 1993; Sarason, 1990; Spillane, 1999).

In the initial years of curriculum implementation research, sociologists and political scientists led the studies amid frustrations at what they perceived as teachers' failures to implement curricula (Berman & McLaughlin, 1976; Cordray & Pion, 2006). However, part of the problem was the fact that these leading researchers were in most cases informed by different theories from their respective backgrounds and took little or no

feedback from teachers, thus side-lining the agents of the implementation process (Rowan & Miller, 2007).

In recent times, those involved in curriculum development have become more engaged in curriculum implementation (Penuel *et al.*, 2009). This positive development implies that the developer becomes concerned and takes into consideration conditions for the effective implementation of the programmes they design (Penuel *et al.*, 2009). The researchers suggest that research on curricula implementation should expand in ways that inform the design of the next curriculum (Penuel *et al.*, 2009). This expansion in implementation research means that teachers also become involved in curriculum design in the same sense that designers engage in the implementation of the new reforms at different stages. Thus, successful reform should consider teachers' needs and the capacity of schools to handle the suggested reforms. Designers should not only focus on what needs to change but also on how that change is going to be effected with the least possible challenges (Blumenfeld *et al.*, 2000; Jansen, 1998). Penuel *et al.* (2009) suggest three dimensions in which programme implementation research should expand:

- Identify opportunities within the current system of education practice when new designs may improve teaching and learning.
- Refine curriculum or aspects of implementation support in ways that can bridge the gap between the current capacity of the system and the intentions of new reforms (the ideal).
- Identify challenges encountered during implementation as the basis for curriculum design.

Thus, over the past decades the expansion in implementation research has risen above the initial stages of forcing teachers to focus on other areas of the design process. Some explanations for the failure of reform implementation focus on the lack of clarity in the goals of the reforms and an absence of clear procedures to supervise the implementation (Spillane, 1999).

Ambiguous reform policies have been identified as barriers to change, as teachers get confused over what they are required to do during the implementation process

(Spillane, 1999; Jansen, 1999). In some cases, reforms have failed to be implemented because they were overly ambitious and failed to take cognisance of the current state of schools and the capacity of teachers to handle the envisaged change (Jansen, 1999).

Other researchers have developed ideas that are progressive along the lines of considering teachers' needs, sense making and teacher concerns (Blumenfeld *et al.*, 2000). Hall and Hord (2015) developed a framework that seeks to remove the barriers to change and postulated that an increased ability to deliver new curriculums, strategies and content positively correlates with the likelihood of the successful implementation of a reform programme. The two other factors that influence the likelihood of success are culture and policy management (Blumenfeld *et al.*, 2000). In effect, Blumenfeld *et al.* (2000) seem to suggest that to increase the likelihood of successful implementation, there should be increased effort focused on changing beliefs as well as deepening understanding and pedagogical expertise. School culture, professionalism, sharing of ideas, taking risks and reflection are important in building cultural capacity (Blumenfeld *et al.*, 2000). Their ideas seem to echo those of the Comprehensive School Reform (CSR), an approach popularised in the 1990s as an attempt to offset the challenges encountered in reform implementation. The findings of the CSR and Blumenfeld *et al.* (2000) seem to point out that to achieve successful implementation, reform efforts must not focus on just one aspect, such as enhancing student performance. If true, these findings suggest that reform in teachers' practices must be achieved with a holistic approach in the whole schooling system, which includes building capacity in culture, capability and infrastructure as well as targeting improvements in the curriculum, instruction, organisation, professional development and parental involvement (Desimone, 2002; Johnson *et al.*, 2014).

Spillane (1999) has made landmark contributions to reform implementation processes. The concept of enactment zones (Spillane, 1999) has gained recent momentum in how it can be used to understand and enhance teachers' perceptions about reforms. Similarities have been drawn between how Vygotsky's zone of proximal development (ZPD) is used with students and the concept of enactment zones and how they can be a catalyst to ease reform initiatives in teachers' practices (Spillane *et al.*, 2002). According to Spillane (1999), enactment zones serve as powerful mediating tools

between reform suggestions and teachers' practices. Enactment zones are operationally defined as "that space where reform initiatives are encountered by the world of practitioners and 'practice'.... that zone in which teachers notice, construct and operationalize the instructional ideas advocated by reforms" (Spillane, 1999: 145). Enactment zones capture teachers' capacity, will and prior practice and interact with the incentives and learning opportunities mobilised by the policy. Spillane (1999) concluded that the extent to which teachers can change the core of their beliefs and practices is largely dependent on their enactment zones. In studies involving teachers faced with reform initiatives, Spillane (1999) concludes that teachers who had changed the core of their practices had enactment zones that extended beyond their individual classroom. Their extended enactment zones include those of other teachers, involve deliberation on the innovations and included knowledge about the resources that may be needed during the implementation process.

There are numerous discussions in the literature about how difficult and challenging reform implementation is and how reform efforts are not easily compensated with the desired results (Blumenfeld *et al.*, 2000). These issues are compounded by the complexities involved in determining how successful implementation has been. Evaluating curriculum implementation is measured by considering the extent to which the implementation has been carried out with fidelity to the suggested reform programme (Bond *et al.*, 2000; O'Donnell, 2008). Some aspects of implementation that can be measured include quality, adherence and exposure. While quality is an indicator of how effectively the techniques or methods of the programme have been implemented, adherence focuses on the extent to which steps and procedures of a reform programme have been followed and exposure focuses on the frequency of the programme units (Dane & Schneider, 1998; Dusenbury *et al.*, 2003; O'Donnell, 2008). Admittedly, quality is not easy to measure or evaluate. Furthermore, more research still needs to be conducted to develop instruments that evaluate the various aspects of implementation more effectively.

In conclusion, reform implementation has evolved over the past decade. The disconnection between those who design and those with a central role in the implementation process seems to be narrowing. Further research needs to be conducted on how the involvement of teachers in the design process influences

implementation and how the involvement of designers in the implementation process may enhance the two processes.

2.3 The topology of curriculum representations during implementation

Curriculum implementation is never straightforward and a framework to comprehend this process in full is therefore needed (Nakedi *et al.*, 2012). Van den Akker (2003) distinguishes between different “versions” of the same curriculum, which is referred to as a topology of curriculum representations. (See table 2.1 below.) These versions are the intended curriculum, implemented curriculum and attained curriculum. The intended curriculum is the *ideal* or vision underpinning the curriculum, the implemented curriculum comprises the *perceived* curriculum, which is understood by teachers and the *operational* curriculum, which occurs in their classrooms, while the attained curriculum comprises the curriculum as learners experience it along with their learning outcomes (Van den Akker, 2003). Nakedi *et al.* (2012) suggested another form of curriculum, which is quite applicable in the context of this study: the published curriculum. This curriculum is communicated in writing.

Table 2.1: Curriculum representations by Van den Akker *et al.* (2008: 6)

Intended	Ideal	Vision (rationale or basic philosophy underlying a curriculum)
	Formal or written	Intentions as specified in the curriculum documents and/or materials
Implemented	Perceived	Curriculum as interpreted by its users (especially teachers)
	Operational	Actual process of teaching and learning (also: curriculum-in-action)
Attained	Experiential	Learning experiences as perceived by the learners
	Learned	Resulted learning outcomes of the learners

Bernstein (1996) theorised how these different curriculum representations interrelate with the different players in the murky terrain of curriculum implementation. According to Bernstein (1996), there are four players in the implementation process of a curriculum: the producers, “recontextualisers”, reproducers and acquirers. The producers create the privileged text of the curriculum; the “recontextualisers” are government officials, academics and teachers; the reproducers are teachers and the acquirers are learners.

There are various levels at which a curriculum can be pitched (Thijs & Van den Akker, 2009), as represented in table 2.2 below.

Table 2.2: Curriculum levels and descriptions (Thijs & Van den Akker, 2009)

Level	Description	Examples
Supra	International	Common European framework of references for languages
Macro	System, national	Core objectives, attainment levels <ul style="list-style-type: none"> • Examination programmes
Meso	School, institute	School programme <ul style="list-style-type: none"> • Educational programme
Micro	Classroom, teacher	Teaching plan, instructional materials <ul style="list-style-type: none"> • Module, course • Textbooks
Nano	Pupil, individual	Personal plan for learning Individual course of learning

While the published, illustrated and examined curricula operate at the national level (macro level), the perceived and operational curricula occur at a more local level

(micro level) such as at the school and the attained curriculum occurs at the individual level (nano level) (Van den Akker, 2003). A curriculum differs at the macro, micro and nano levels from one context to another and these elements can thus be multi-dimensional. At the macro level, the producers have a vision that they communicate through the published curriculum. The “recontextualisers” then provide the illustrated curriculum, which the teachers (the reproducers) recognise as the perceived curriculum and implement it as the operational curriculum at the micro classroom level (Nakedi *et al.*, 2012). The learners acquire the attained curriculum at the nano level, which is assessed through the macro level curriculum that is generated by the “recontextualisers”.

Teachers’ curriculum sense making occurs at the micro level, and it is at that level that they infuse their creativity and plan their lessons in accordance to the context and background they find themselves teaching. For science teachers, that implies making efforts to graft science classroom concepts onto what their learners already know and in the process, develop meaningful learning (Wandersee & Griffard, 2002).

Curriculum implementation is observed as occurring in two phases: the envisioned phase and the enacted phase (Nakedi *et al.*, 2012). According to Nakedi *et al.* (2012), the illustrated curriculum serves as a bridge between the two phases. Furthermore, there is some overlap between these phases while the first cohort of learners progresses through a new curriculum. Once the first national examinations are based on a new curriculum, the envisioned curriculum phase is complete and the enacted curriculum phase is operational (Nakedi *et al.*, 2012).

However, discrepancies emerge in the different curricula. Policymakers do not and neither can they, capture their vision exactly in the published curriculum and teachers understand the published curriculum based on their own contexts and experiences, making their own sense of the published curriculum (Nakedi *et al.*, 2012). The operational curriculum and the perceived curriculum will also differ from one locality to another due to the different contexts in the different localities. Furthermore, teachers’ curriculum intentions do not always perfectly mirror the way the learners experience the curriculum. There may thus be a significant gap between the original vision of the producers and the learning outcomes of the acquirers (Nakedi *et al.*, 2012). The

examined curriculum provides a lens through which to consider these outcomes. However, a lens distorts, emphasising some aspects while failing to notice others (Nakedi *et al.*, 2012). Overall, the cumulative effect of small shifts with each translation may be a significant curriculum drift (Nakedi *et al.*, 2012). I am of the opinion that this drift makes curriculum implementation even more complex. If these representations are not well comprehended by the producers, “recontextualisers” and reproducers, each group of players can go in their own directions and fight for their own interests, resulting in increased implementation challenges.

The solution to this complex scenario can only emerge from bridging the gaps between the different curriculum representations (Barnes, Clarke & Stephens, 2000; Nakedi *et al.*, 2012; Van den Akker, 2003). According to Van den Akker (2003: 5), “careful alignment between [the] assessment and the rest of the curriculum appears to be critical for successful curriculum change”. Congruency between the published, illustrated and examined curricula is thus critical for effective curriculum implementation (Nakedi *et al.*, 2012).

The different curriculum representations cited above are not the only perspectives on the curriculum elements. Goodlad (1994) distinguished between three different lenses through which different stakeholders may view the same curriculum. I summarised these perspectives on curriculum in table 2.3 below.

Table 2.3: Perspectives on curriculum (Goodlad, 1994)

Perspective	Description
Substantive	Focusing on the classical curriculum question regarding what knowledge is of most worth for inclusion in teaching and learning.
Technical-professional	Referring to how to address the tasks of curriculum implementations, especially the challenge of how to bridge the gaps between intentions, realities and outcomes.
Socio-political	Referring to the curriculum decision-making processes, where values and interests of different stakeholders and agencies are at stake.

During curriculum implementation, various stakeholders place different emphases on diverse perspectives, as they pursue their own interests. For example, when Jansen (1998) noted that recent curriculum failures in South Africa were due to policymakers placing more emphasis on the “what” rather than the “how” of curriculum implementation, the technical-professional perspective was the focus. Yet, a government official may not easily comprehend that emphasis, as s/he may be more focused on the socio-political perspectives. Hence, in the same paper Jansen (1998) proposes that analysis of curriculum implementation should be two-fold; technical and political, both of which are equally valid.

Careful alignment between assessment and the rest of the curriculum appears to be critical for successful curriculum implementation. Stakeholders should keep this in mind during development, implementation and evaluation of the reforms.

In their critical analysis of current reform efforts in South Africa, Nakedi *et al.* (2012) concluded that there is a lack of congruency between the published, illustrated and examined curricula. However, they credit the current CAPS for internal consistency.

2.4 The concerns-based adoption model: The conceptual framework

The realisation and acceptance that teachers are the real agents of change in curriculum reform in the 1970s gave birth to research-based programmes that sought to aid reform by addressing teachers’ concerns (Holloway, 2003). Fuller’s (1969) framework lays the foundation for studies about teachers’ concerns regarding educational innovations and reforms. Fuller (1969) categorised teachers’ concerns into three stages: impact, self and task concerns. Impact concerns are about teachers’ worries pertaining to the students’ outcomes, self-concerns relate to the ability of the students to perform in the school environment and task concerns are about the obstacles in the daily teaching duties such as the lack of resources and large classroom sizes.

The concerns-based adoption model (CBAM) is a research-based framework and methodology developed in the 1960s and 1970s for the evaluation, description, measurement and explanation of various aspects of reform implementation by teachers (Holloway & Anderson, 1997).

There are 12 assumptions about change that underpin the three diagnostic instruments of CBAM. Hall and Hord (2001) defined these as follows:

- ✓ Change is an ongoing process, not a single event.
- ✓ The development and implementation of one innovation is significantly different from that of another innovation.
- ✓ An organisation does not change until the individuals within the organisation change.
- ✓ Innovations come in different levels of intensity and in different forms.
- ✓ Interventions are actions and events that are important to bringing about successful change.
- ✓ Although top-down and bottom-up perspectives of change can work, horizontal perspectives of change are best.
- ✓ Administrative leadership is essential to the long-term success of change.
- ✓ National, state and district mandates can work for schools when implementing change.
- ✓ Schools are the primary units of change.
- ✓ Facilitating change is a team effort.
- ✓ Appropriate interventions reduce the challenges of change.
- ✓ Contexts of schools' influence processes of change.

The far-reaching argument of the CBAM is that if policymakers are to assist the agents of the implementation, such as teachers, then they must take cognisance of teachers' concerns (Hall & Loucks, 1978). As the implementation proceeds, teachers' concerns evolve through the different stages and hence the model should not be considered as a one-time event, but rather a continual process of programme implementation and curriculum reforms (Hall & Hord, 1987; Isabel, 2013). During the implementation process, regular teacher-support is imperative if the reforms are to yield the expected outcomes. The CBAM thus, through different instruments, enables the monitoring of the reform implementation process and the development of support strategies for teachers in their different stages of aligning themselves with the reform ideas as envisaged by policymakers (Nielsen & Turner, 1978).

The CBAM also seeks to address the inherent nature of most human beings to resist change. There are suggestions for dealing with resistance against change which

includes assisting the stakeholders to acknowledge change as a process, empowering the stakeholders, encouraging the stakeholders, setting concrete goals, being sensitive, modelling the process skills, dealing with emotions, managing conflict, communicating and managing process dynamics (Hall & Hord, 2015; Holloway, 2003; Turks & Weller, 2001). Sternhouse (1978) suggested that resistance might not necessarily be the cause for change being difficult; it is rather the barriers to change that are challenges to the reform efforts. The removal of barriers to change cannot be done at a once-off workshop. Instead, regular, continual support that probes teachers' concerns ensures effective change management (Hall & Hord, 2015; Turks & Weller, 2001).

In recent times, research has confirmed the correlation between individual teachers' concerns and the successful implementation of the reforms and innovations in education. Addressing teachers' concerns can thus assist in developing continuous support programmes that assist teachers during the implementation (Holloway, 2003; Senger, 1999). These concerns can be described as reactions, thoughts and feelings that teachers develop with regard to curriculum changes (Hord *et al.*, 1998).

CBAM instruments

The CBAM consists of three tools, namely the level of use (LoU) questionnaire, the stages of concern questionnaire (SoCQ) and the innovations configurations (IC) questionnaire. These diagnostic instruments may be used in a variety of ways to document the implementation of a reform. Each of the three diagnostic instruments may be evaluated alone, together or in any combination to give a holistic perspective of change (Hall & Hord, 1987). These instruments are used to conceptualise the change process during reform implementation. Stages of concern are used to describe the affective component of change. Levels of use assist researchers to diagnose how individuals act during the change process and innovation configurations are used to describe different operational patterns of change. Below I describe each of these diagnostic tools in more detail.

The stages of concern questionnaire

The successful implementation of an innovation critically depends on identifying the concerns of individuals who are involved in the innovation (Hall and Hord, 1987). The stages of concern (SoC) is the first instrument of the theoretical framework of CBAM. The SoC instrument incorporates the feelings and emotions that teachers might have during times of curricular change (Anderson, 1997). According to Hall and Hord (1987), there are seven developmental stages of concern: unconcerned (Stage 0), informational (Stage 1), personal (Stage 2), mechanical (Stage 3), consequence (Stage 4), collaboration (Stage 5) and refocusing (Stage 6). The stages of concern questionnaire (SoCQ) enables the evaluation of these seven stages of concern. Once researchers have identified the general concerns of the group, they may be able to categorise stages of concern of the group and its individual members and plan ways to support movement to a higher developmental level. Below I give a brief description of the seven stages of concern as elaborated by (Hall & Hord, 1987).

Awareness: Teachers do not worry much about the reforms and have little interest in being part of them. In most cases, they are not aware that they are the important agents of change.

Informational: Teachers are willing to learn more about the reforms. They express concerns about the innovations and are worried about how the change could be implemented.

Personal: During this stage, teachers are concerned about how the reforms will impact them.

Management: Teachers who show this level of concern will be more concerned about how they could effect the changes in the classroom in alignment with the suggested reforms. They are also worried about how these changes will impact their time management.

Consequences: When teachers are in this stage, they question how the reforms will impact their learners' performance. If the impact is perceived to be positive, then they are more likely to have a positive attitude towards the changes.

Collaboration: Teachers are more engaged in the reform process and they are more willing to engage with other teachers in a spirit of learning and to exchange ideas to make the implementation more successful.

Refocusing: These teachers already think in a similar way as the reformers or policy makers. They evaluate the reforms and look at ways in which the reform process and the implementation can be improved for better results.

Levels of use

The second component of the CBAM is the level of use (LoU). The levels of use tool consists of eight behavioural profiles that describe the actions that educators engage in as they become more familiar with and skilled in using an innovation (Hall & Hord). The LoU interview protocol enables researchers or policymakers to know the extent to which teachers are using a new innovation. Researchers can also determine whether individuals are at an initial stage or at a more advanced level, in their expertise and experience in using the programme. Equipped with this knowledge, authorities can formulate strategies necessary to assist teachers and enhance the implementation.

According to Hall and Hord (2006), the following are the eight levels of use: non-use, orientation, preparation, mechanical, routine, refinement, integration and renewal. The objective in determining individuals' levels of use of change is to assist them progress through the seven stages of concern in CBAM (Hall & Hord, 2006). As individual teachers progress through the eight LoU, they would correspondingly progress from the lower stages of concern such as unconcerned or personal to higher stages of concern such as collaboration and refocusing (Hall & Hord, 2006).

Innovation configuration

The third CBAM instrument or concept is the innovation configuration (IC) and it defines individuals' variations in the use of an innovation (Hall & Hord, 2006). Innovation configuration permits policymakers to track individuals' progress during change and to implement additional innovation practices that might be required for successful integration of change. The purpose of innovation configuration is to

describe the operational patterns that reforms can take. How this diagnostic instrument is developed depends on how a particular innovation is defined and used.

It is necessary to define or configure innovations because different users of innovation operationalise the innovation in divergent ways (Hall & Hord, 2001). The key to understanding IC at institutions undergoing change, according to Hall and Hord (2001), lies in finding appropriate responses to the following questions:

- ✓ What does the reform look like when it is operational?
- ✓ What would I see in classrooms when the innovation is used well (and not so well)?
- ✓ What will teachers and students be doing when the innovation is in proper use?

For this study, only the stages of concern instrument was used.

2.5 Teachers' perspectives during reforms

A key dimension of the reform implementation process that is seldom explored is teachers' sense making regarding innovation initiatives (Spillane *et al.*, 2002). How teachers arrive at their own meaning of what the reform requires them to do is a result of many different factors, among them their existing cognitive structures, environmental situation and the policy signals.

Regarding cognition, Spillane *et al.* (2002) explored teachers as individual sense makers, taking note of how individuals notice and interpret stimuli and how prior knowledge, beliefs, values, emotions and experiences influence the construction of new understanding. This sense making is not divorced from the situation or environment in which the agent is situated. Context is thus critical in understanding how teachers make sense of reforms.

Furthermore, the type of stimuli that teachers receive is critical to the sense making process. If the signals from policymakers are ambiguous or vague, then teachers' sense making could differ widely from the intention of the reform directives. Thus, some programmes have failed during the implementation process due to a lack of formulation of clear policy outcomes and directives (Spillane *et al.*, 2002). When a policy is developed because of compromises and consensus building between

different coalitions, it often causes ambiguity for the end users or the agents of the reforms. For example, in South Africa, it has been argued that this aspect is the reason for the failure of C2005 at the implementation stage. The likelihood of successful implementation also depends on what aspects of teachers' classroom practices are being targeted for change and at what pace the change is expected to take place. Policies that advocate for an incremental change are more likely to be implemented (Spillane *et al.*, 2002). When clarity concerning the implementation, goals is accompanied by procedures that are easy to follow, curriculum reform implementation is enhanced (Spillane *et al.*, 2002; Brewer & Nakamura, 1984; Greeno, Collins & Resnick, 1996).

There have been instances where failure to implement the reforms on the part of teachers is explained in terms of a lack of capacity or an unwillingness to cooperate (Spillane *et al.*, 2002; Brewer & Nakamura, 1984). However, most research has proven that the majority of teachers and administrators are willing to cooperate and take directives from their superiors if the appropriate space for their own sense making is allowed (Spillane *et al.*, 2002; Brewer & Nakamura, 1984). Sense making is not simply taking policy directives and decoding them. It is an active process of making meaning dependent on everyone's knowledge base, beliefs, attitudes and emotions (Carey, 1985; Rumelhart, 1980). Furthermore, it is a process fertile with ambiguities and difficulties. Most agents of change tend to find it easy to cooperate with reform ideas that serve their interests (Spillane *et al.*, 2002). Their prior knowledge is critical to sense making and forms the bedrock on which new meaning is actively constructed (Brewer & Nakamura, 1984; Greeno *et al.*, 1996). What individuals notice in their environment and how they notice it depends on their prior knowledge, their beliefs and expectations about the manner in which the world works. An individual makes sense of his/her environment by relating different concepts through schemas, which encode causal theories about how the world works (Spillane, 1999). Different teachers will thus understand the stimuli from policymakers differently, each seeing what is new in terms of what is already known and believed (Spillane *et al.*, 2002). This author would add that this could be the reason why some teachers may be found in the collaboration stages of implementation while other teachers' practices have not changed at all. However, in both cases, both sets of teachers may be convinced that they are implementing the changes and that their "new practices" are aligned with the reform

efforts. Teachers who have good intentions and are willing to cooperate (Spillane *et al.*, 2002) may even interpret the same message differently. In some cases, teachers may be convinced that the new reforms are quite familiar to them and hence will not see “much” change between the new and the old, thereby hindering the reform efforts (Spillane, 1999). Strike and Posner (1992) concluded that fundamental change, which requires a restructuring of existing knowledge, is extremely challenging.

Apart from the cognitive aspects of sense making, Spillane *et al.* (2002) also discuss other aspects that impact an individual’s sense making of policy and reach interesting conclusions. Values and emotions are key to sense making, historical context affects its implementation, it is affected by the organisational context, social interactions can shape it in implementation, it occurs in a social context, the affective costs of self-image can work against adopting reforms and people are biased towards interpretations consistent with their prior beliefs and values (Spillane *et al.*, 2002).

2.6 Fidelity of curriculum implementation

Fidelity of curriculum implementation (Fol) is the degree of alignment between how the curriculum is implemented and how the policymakers envisaged the implementation (Berman & McLaughlin, 1976; Dane & Schneider, 1998; Dusenbury *et al.*, 2003; Mihalic, 2002). Thus, it is the measure of how small the “implementation gap” is. From the 1970s, the concept of Fol has developed especially in addressing health related problems such as drug abuse in the United States (Dane & Schneider, 1998; Dusenbury *et al.*, 2003). In education reforms, many authors have contributed to the growing significance of the concept, discussing different perspectives, identifying factors that increase fidelity and effectiveness of reform programmes (Remillard, 2005; Songer & Gotwals, 2005; O’Donnell, 2008; Vartuli & Rohs, 2009). There are several reasons for studying the fidelity of implementation. It sheds light on why the implementation fails or succeeds, it allows researchers to identify those aspects that have changed and how these affect outcomes and lead to recommendations on possible adjustments to the programme to close the implementation gap (O’Donnell, 2008). According to Dusenbury *et al.* (2003), fidelity of curriculum implementation studies assist in evaluating the feasibility of the study. A comparison between the new and old programme and an in-depth study of the philosophical and practical reasons for curriculum changes are indispensable to any

studies on implementation fidelity. In the South African context, the DBE should be commended for ensuring that such a study to compare NCS and CAPS was undertaken (UMALUSI, 2014). The resulting UMALUSI report is the subject of discussion in sub section 2.8.1. Further studies, specifically on fidelity of implementation, are needed in the present reforms.

2.7 Implementation integrity and actor-oriented perspectives

Integrity and actor-oriented are two perspectives that curriculum designers and researchers may orient themselves towards for their studies and for developing the curriculum (Penuel *et al.*, 2014). Integrity is an outsider's view of the way that teachers' interpretations of curriculum materials align with curricular objectives, principles and theories (Penuel, Phillips & Harris, 2014). Thus, some resonance exists between this perspective and the concept of fidelity. This is because implementation integrity researchers centre their attention on the extent to which educators' practises align with guidance outlined in curriculum documents, maintain integrity with the philosophical and theoretical principles of the designs and provide learners with adequate exposure to opportunities to learn during the teaching and learning process (Dane & Schneider, 1998; Penuel *et al.*, 2014). Contrary to the integrity perspective, an actor-oriented perspective focuses on teachers' sense making and interpretations of curriculum documents and the manner in which these perceptions shape their decisions and practices (Lobato, Rhodehamel, & Hohensee, 2012; Penuel *et al.*, 2014). Through the actor-oriented lens, curriculum implementation researchers seek to explore the relationships between teachers' decisions, practices and what they interpret to be curricular intentions as well as how these interpretations are shaped by their previous experiences and contexts (Penuel *et al.*, 2014). Actor oriented researchers assume that implementing new programmes presents situations that demand teachers to draw connections between curricular goals and structures and the goals and structures of the old and the new curriculum (Penuel *et al.*, 2014).

In both perspectives, a clear understanding of the differences between the new and the old programme is indispensable. Besides researchers, curriculum designers also align themselves with either of these perspectives. For designers committed to the integrity perspective, the approach to simplifying curriculum documents becomes a top priority as they envisage a more technical teachers' role. On the contrary, actor-

oriented designers are more inclined to leave more allowance for teachers' creativity and hence curriculum documents are less restrictive.

2.8 Curriculum changes in post-1994 South Africa

After 1994, the South African government, through the DoE, introduced several changes that sought, and still seek, to improve the education system: Curriculum 2005, the National Curriculum Statement (NCS) and, most recently, Curriculum Assessment and Policy Statements (CAPS) reforms. If the main objective of introducing C2005 was an attempt to bridge the disparity gap in the distribution of resources brought about by the apartheid system, then NCS sought to emphasise that learners ought to become critical thinkers and problem solvers. Teachers were supposed to drive the change from a traditional content-driven, teacher-centred-process approach to a learner-centred approach. The changes were necessary and served their purposes at the respective times. However, the success of any programme is only as good as the effectiveness of the implementation process.

Gaining clarity on how the new CAPS curriculum is different from the old NCS curriculum is an important initial step for educators, if they are to be effective agents of change. Sternhouse (1983) observed that a lack clarity regarding reform ideas is one of the barriers to change in teachers' practices, despite their best intentions and efforts to change and accept the education innovations.

2.8.1 Formulating a theory of comprehensive curriculum implementation in South Africa

The curriculum changes in the post-1994 era have attempted to confront challenges in curriculum implementation in the South African education system. However, in these attempts, further implementation challenges have come to the fore. All stakeholders, including policymakers and teachers, must consider these challenges as opportunities to learn. Curriculum implementation remains rich, fertile ground for further research.

Through a series of studies, some have sought to develop a theory of curriculum implementation in South Africa based on C2005 (Rogan, 2000; Rogan, 2004; Rogan, 2007a; Rogan & Aldous, 2005; Rogan & Grayson, 2003). Through the Mpumalanga Secondary School Initiative, Rogan and others pointed out that efforts towards

reforming science education in most developing countries seem to be flawed in that well-intentioned programmes lack detail regarding how the implementation should be carried out at school level. These programmes do not consider disparities between schools but rather present a one-size-fits-all approach, which leads to frustrations and challenges in different environments (Rogan & Grayson, 2003). The conclusion is that most programmes, including C2005, are well developed and only fail in the implementation stages, concurring with previous studies carried out elsewhere (Holloway, 2003; Spillane *et al.*, 2002; Sternhouse, 1983).

One way to overcome barriers during the implementation process is to allow teachers to be part of the process by giving them ownership of the content and curriculum reform efforts (Rogan, 2000). While I concur with this idea, it could further be suggested that teachers should even be involved during the initial developmental process of the curriculum. This could be done by asking for their input on curriculum changes. Teachers should not be made to feel as if change is being imposed on them from “above” because, by the time such a curriculum is launched, teachers could already be disgruntled at having yet another change imposed upon them and be less likely to cooperate fully from the start, as they already feel marginalised.

Rogan (2000) proposes a South African curriculum framework that recognises the diversity in South African schools rather than seeking a one-size-fits-all approach that is characteristic of the recent approaches. Rogan (2000) further proposes three constructs in curriculum implementation, namely implementation profile, capacity to innovate and outside support.

The zone of feasible innovation (ZFI) parallels Vygotsky’s ZDP. Reforms should not exceed the current practices by too large a gap (Jansen, 1998). Different implementation strategies should be developed at each school per its stage of development. This author would further argue that the ideas of ZFI should be emphasised together with the concept of enactment zones proposed by Spillane (1999). Too large a gap between teachers’ current practices and the demands of innovation could lead to frustration and failure during the implementation process. Outside consultants, called “outside support” by Rogan and Grayson (2003), could help teachers by exploring individual teachers’ enactment zones and providing some

form of “scaffolding”. Rogan’s (2003) suggestions for focusing on whole school development rather than simply targeting one aspect of the school, such as enhancing performance, echoes CSR (Desimone, 2002) as much as fitting into Jansen’s (1998) suggestions regarding whole school development.

2.8.2 Curriculum 2005

The background to the development and the subsequent launching and implementation challenges in regards to Curriculum 2005 have been the subject of discussion by various researchers (Chisholm *et al.*, 2000; Chisholm, 2003; Fataar, 2000; Jansen, 2009; Rogan & Grayson, 2003; Chisholm, Volmink, Ndhlovu, Potenza, Mahomed, & Muller, 2000). The DoE launched C2005 in 1997 and it was aimed at the General Education and Training (GET) and Further Education and Training (FET) phases (DoE, 2006). The launch of C2005 was accompanied by political connotations as it sought to overturn the legacy of apartheid and hence signalled an attempt to break away from the previous policies (Chisholm *et al.*, 2000). C2005 laid down the vision for general education to move away from and teacher-centeredness to learner-centred outcomes-based system (Chisholm *et al.*, 2000). The curriculum 2005 was based on the premise that all learners must be permitted to learn to their full potential (McDonald & Van der Horst, 2007). The authorities intended C2005 to be a coherent policy initiative that would transform the teaching and learning process (Fataar, 2000). If the reform had been successfully implemented, it would have resulted in a drastic shift in education practices as it ushered in an emphasis on learner-centeredness, OBE and an integrated approach to knowledge (Chisholm *et al.*, 2000). C2005 set certain outcomes that learners should be able to demonstrate at the end of the process, if successful learning had taken place. C2005 demanded a new role from teachers to give effect to a learner-centred approach in which the teacher was expected to become a facilitator of learning rather than the sole repository of knowledge (DoE, 1997).

Opinions and perspectives are widespread regarding the failure of C2005 to meet expectations. Jansen (1998) had predicted that C2005 would fail, citing that it was idealistic and overly ambitious, especially considering the economic and political climate of the time. Other researchers (Rogan, 2004; Rogan & Grayson, 2003) suggest that the failure of C2005 could be attributed to an emphasis on the “what”

rather than on the “how” of the reform programme. Jansen (1998) further alludes to the holistic approach needed to overhaul the whole education system if real change is to take place, which seems to echo the ideas of CSR deliberated in some sectors of the American system (cf. section 2.2).

2.8.3 National curriculum statement: Implementation challenges

Challenges in the implementation of C2005 resulted in a review just two years after its launch, which led to the DoE introducing a replacement, the revised NCS for grade 9 to 12 in 2002 followed by grades 10-12 in 2003 (DoE, 2003). Further developments led to the revised NCS being adopted as NCS. The NCS innovation in physical sciences education placed more emphasis on critical thinking and problem solving in learners (DoE, 2003). This was an enormous departure from the traditional teacher-centred, content-driven approach, which encouraged rote learning and memorisation of ready-made scientific information. Thus, NCS sought to change teachers’ practices from a traditional approach largely based on delivering content to one where they would organise the classroom environment to enhance knowledge construction by learners. The following are characteristics of the traditional approach, as summarised by Fink (2003):

- Emphasis is on memorisation and rote learning.
- Assessment is largely through pencil and paper tests and examinations.
- Knowledge is “delivered” by the teacher as learners passively “receive” it.
- Little emphasis is placed on cooperative learning and problem solving.

In contrast, according to DoE (2006), NCS demanded that teachers must be able to:

- organise classroom learning environments to enhance learners’ ability to develop skills, construct knowledge and foster values and positive attitudes relevant to physical sciences; and
- fully understand the physical sciences content and scientific methods as well as the application of the scientific knowledge to solve problems.

The NCS was more focused on the outcomes and therefore was set at the national level, as it left schools and teachers to make their decisions at the meso and micro-levels of the curriculum respectively. Thus, while C2005 focused mainly on correcting the imbalances of the previous era through the reorganisation of the curriculum

(Jansen, 1999), the NCS sought to move beyond mere reorganisation by giving expression to the value of democracy, human rights, social equity and justice (Department of Education, 2003).

General challenges confronted during NCS implementation included such as inadequate resources, financial constraints and lack of training, increased workloads including administrative paper work for educators (Badugela, 2012). Interventions to improve NCS implementation had not yielded the desired effect (UMALUSI, 2014). Further challenges in the implementation of NCS resulted in another review in 2009 that then led to the new CAPS documents, which will be discussed below (Section 2.8).

2.8.4 Challenges and dynamics of curriculum reforms in South Africa

Dynamics are the issues and tensions, the factors that hinder or help; the constraints, possibilities or difficulties of policy implementation (Hunter & Marks, 2002). The concept of dynamics evolves from Gunn's 1978 list of difficulties regarding the implementation of new policies (Hunter & Mark, 2002).

Numerous dynamics have been identified surrounding the C2005 implementation. These dynamics include some educators perceiving a political agenda surrounding C2005, the demand for a new educator role, a bottom-up or top-down process, teacher's workloads, teachers as central agents of implementation and teachers' identities during times of change. Additional dynamics include contradictory messaging from authorities before and during reform implementation, the philosophy or worldview behind curriculum reform and lastly, the impact (on teachers) of the general and socio-economic conditions before and during reform implementation (Treu *et al.*, 2010).

Most of these dynamics have been repeatedly cited as obstacles to curriculum reform implementation in South Africa and abroad; hence, their understanding may lead authorities and policymakers to anticipate how best they can be offset during the present and future implementations. In some cases, these dynamics can be averted or ameliorated during the curriculum implementation phases and in some cases, new curricula have been developed to address the negative impact of these dynamics. I am of the opinion that paying close attention to these dynamics on the part of

policymakers, teachers and other stakeholders may assist in avoiding the implementation pitfalls that have befallen previous curriculum efforts.

Political agenda as a dynamic in this curriculum cycle might not have been as significant as in the previous cycles that were characterised by a need to correct the imbalances brought on by years of inequality in the South African society. However, the emphasis on matric results might have become more political than usual as evidenced by the reports in the media in the days surrounding the announcement of these results. Stakeholders would do well in understanding how these new developments may influence the current implementation.

The demand for a new educator role is probably one of these important dynamics and therefore a new curriculum would entail clearly spelling out what this role is so that this becomes clear to the teachers since they will still be leaving a role for their own sense making. New teachers' roles during curriculum reforms are also closely related to how they grapple with new identities during times of change.

Messaging from policymakers and other authorities can enhance implementation or become an obstacle if it is ambiguous or contradictory. This dynamic is also related to how teachers interpret curriculum documents. Reducing the amount of these curriculum documents and improving clarity have become priorities to policymakers as they seek to reduce ambiguity and confusion on the part of teachers.

The general socio-economic conditions of teachers have also been cited as affecting reform implementation (Treu *et al.*, 2010; Treu, 2010; Waghid, 2007; Chisholm, 2003). Evans (1999) points out that successful curriculum implementation is dependent on teachers' positive attitudes and high levels of morale and motivations, which are usually undermined in times of unfavourable socio-economic conditions. Dwindling resource supplies have already been cited as negatively affecting previous curriculum reforms (Le Grande & Reddy, 2000; McGrath, 2000).

2.8.5 CAPS: New curriculum or repackaged NCS?

According to Nakedi *et al.* (2012: 273), "CAPS [was] introduced in response to [the] confusion precipitated by [the] previous curriculum documents". Thus, challenges have mainly been experienced in the implementation process of the reforms rather than with curriculum development.

Current curriculum changes in South Africa have generated debate regarding what constitutes a new curriculum and what is a “repackaging” of the curriculum. As an implementation researcher, I have also found myself reflecting on what kind of curriculum change is necessary at a time or in a particular situation: A new curriculum or a repackaging of the old. While clear definitions may assist researchers, policymakers and implementers, the literature does not seem to provide satisfactory answers to this question, possibly because between the extremes of a completely new curriculum and a repackaged curriculum there are intermediates, making the range difficult to demarcate clearly.

A new curriculum is developed and introduced when it is believed the old curriculum cannot adequately ensure students’ acquisition of knowledge and skills deemed necessary for adapting to the changing conditions of the world. Significant overhauls of the curriculum result in changes to subject content and oftentimes to philosophical, theoretical and pedagogical principles. Repackaging occurs when the present curriculum is not being implemented with close enough fidelity and there is a large gap between what the policymakers intended and how teachers are implementing it, leading to a change known as “adaption” or “repackaging”, the sole effort being to improve implementation. Ideally, a new curriculum is significantly different from the old curriculum in terms of philosophical and theoretical principles as well as in subject content while a repackaged curriculum has fundamentally similar philosophical and theoretical principles and may have changes in subject content.

2.9 Curriculum and Assessment Policy Statements (CAPS)

CAPS replaced the NCS documents. Currently, there is debate about whether the CAPS curriculum is a completely new curriculum or whether only superficial changes have been made to ease implementation of the positive aspects of NCS. However, departmental documents are clear that a series of implementation challenges lie behind the most recent curriculum changes from C2005 to presently, CAPS (DBE, 2011). The national curriculum in South Africa is still called NCS grades R to 12. It represents a policy statement for teaching and learning in South African schools and consists of:

- CAPS for all approved subjects;

- the national policy for the programme and promotion requirements of NCS grades R to 12; and
- the national protocol for assessment of grades R to 12.

Furthermore, learning areas are now referred to as subjects. There is also reduced paperwork for teachers to do. The use of terms such as “learning outcomes” and “assessment standards” has been replaced with specific content skills to be achieved in the form of knowledge and skills. The CAPS curriculum seeks to remove some of the bureaucratic red tape of NCS to ease the implementation of the reforms. The “updates” have resulted in changes of varying degrees in different subject areas, ranging from minor to major, concerning aspects such as assessment, cognitive levels and content. These changes need to be clarified and understood by all stakeholders, especially by teachers.

In any curriculum reform process, teachers should clearly understand the intention of the policymakers. Educators need to have a comprehension of curriculum documents and an understanding of the curricular purposes and structures to organise instruction effectively and facilitate learning (Penuel *et al.*, 2014). Workshops to prepare teachers for the new curriculum could be helpful to teachers in analysing and comprehending the philosophical underpinnings and reasons behind the reforms. However, understanding the theoretical and philosophical motivations behind reforms requires quality control type studies that would compare the new and the old curriculum. The Department of Basic Education tasked UMALUSI, South Africa’s council for quality control, to carry out such a study in the transition from NCS to CAPS.

2.9.1 The UMALUSI report: Evaluating CAPS

The Department of Basic Education (DBE) engaged the Council for Quality Assurance in General and Further Education and Training (UMALUSI), to “quality assure the newly developed Curriculum and Assessment Policy Statements for Grades R–12” (UMALUSI, 2014: 19). This led UMALUSI to carry out a comparative study on NCS and CAPS, the results of which are published in an overview report. Below I summarise their findings, in most cases limited only to those aspects that pertain to physical sciences and classify them under categories such as the teacher’s role and learner’s role, curriculum framing and concepts such as content breadth and depth,

sequencing, progression, coherence and how to determine the weighting and curriculum focus in the documents.

The analysis reveals that the shift has been towards a much more technical and traditional approach toward teaching and learning (UMALUSI, 2014). The CAPS curriculum reduces a learner to being a mere recipient of a body of pre-determined knowledge (UMALUSI, 2014: 42). The intention to develop critical thinking about knowledge validity and bias as captured in some NCS learning objectives (LOs) are not included in CAPS. Probably, to counter the emphasis on group work in NCS, CAPS has gone to the extreme of emphasising individual work instead of seeking a balance. This is in sharp contrast not only to NCS that sought to create a class environment in which the learner is an active participant engaged in the construction and negotiation of meaning with the teacher and his/her peers but also represents a shift from where most of the research findings of the past four decades have been heading towards. Research findings have been heading towards a constructivist approach to teaching and learning.

The theoretical framework for constructivism is Piaget's work with followers such as Bruner and Ausubel (Liu & Mathews, 2005, Wertsch, 1985, von Glasersfeld, 1995). Proponents of this theory focus on the intrapersonal nature of individual knowledge construction. Knowledge is not transferable from person to person but individuals actively construct their own knowledge. For constructivists, the teacher's role becomes that of a source of stimuli that ensures a conducive environment for the learner to construct their own knowledge through cognitive conflict. Vygotsky's work lays the theoretical framework for an approach to learning known as social constructivism. According to Vygotsky and his followers, including Kuhn, Greeno, Lave and Brown, the social environment is central to the learning environment while the learning is context specific and content bound (Eggen & Kauchak 1999; Veer & Valsiner, 1993; Woolfolk, 2001).

Where NCS clearly articulates the teacher's role, the CAPS curriculum does not refer to the teacher's role (UMALUSI, 2014: 15) but this can only be inferred, compared to the defined learner's role and other references to the teaching and learning process. The significance of the teacher's role has become greatly diminished in CAPS,

implying that “...educators are being reduced to implementers of a predetermined learning programme, as opposed to having flexibility in the design and adaptation of the learning programme...” according to the needs of their learners and their context (UMALUSI, 2014: 15). The rigidity imposed by such a tight specification of content and time has been judged to have an adverse impact on the teaching and learning process, especially if implementation is intended to be literal (UMALUSI, 2014). Teaching programmes have been provided for teachers with the clear, overriding assumption that educators lack expertise. Ironically, however, CAPS programmes require highly skilled teachers to judge the depth and pace of progression, as little guidance is provided (UMALUSI, 2014).

With regard to curriculum levels (section 2.3), UMALUSI concludes that while NCS was set at the macro level, leaving teachers to organise the teaching and learning at the micro level, CAPS is an instructional programme that represents a shift to the meso level or even micro level with its higher degree of specification of content, sequencing and pacing (UMALUSI, 2014). Concerning physical sciences, the report specifies prescribed activities and timeframes, leaving the teacher with little room to be creative or to create a teaching environment that is cognisant of learners’ particularities. This has also resulted in a greater length of subject related documents that the physical sciences teachers need to consult.

UMALUSI (2014) reports that CAPS offers learners limited opportunities for the development and practice of creative, analytical and synthesising skills. It is concerning that there has been a shift from a constructivist discovery and learner-centred approach to a more teacher-centred, technical, content-driven and results-oriented curriculum. The CAPS curriculum reduces teaching and learning to technical instruction with academic performance as the single most important indicator of educational achievement (UMALUSI, 2014). The argument for constructivism over previous years has been that it offers the best opportunities for the development and practice of creative, analytical and synthesising skills. The South African Department of Basic Education outlines as principles, under general aims, that the teaching and learning process should encourage an active and critical approach to learning, as opposed to passive, rote and uncritical learning of given truths (DBE, 2011). Research has proven that a teacher-centred approach that is content driven and in which the

learner is a passive recipient of pre-determined knowledge offers fewer possibilities for the development of higher level cognitive skills such as critical thinking (Eggen & Kauchak, 1999; Woolfolk, 2001).

A simpler language in CAPS, which is used to describe the teaching and learning process, has replaced the complex jargon that characterised the previous curricula. Teachers' work overload has been previously identified as an obstacle to curriculum implementation; hence, one of the recommendations in CAPS has been a revision of the aspect, especially considering that a balance must be reached regarding content breadth and depth (Schwartz *et al.*, 2008). There is a reduction in breadth of content in FET physical sciences (UMALUSI, 2014) but no significant difference in depth. On pacing, the CAPS curriculum is characterised by strict timeframes and faster pacing is required to complete the syllabi at each level of FET.

The sequencing and progression of topics in physical sciences is not that consistent with recent research findings and often interrupts the required flow (UMALUSI, 2014). An example of this is physical sciences, where the grade 10 CAPS interrupts the flow of certain chemistry topics with the arbitrary insertion of unrelated physics topics, causing a break in the conceptual progression of learners (UMALUSI, 2014: 53). I am of the opinion that the break in progression in physical sciences is not easily avoided because of the compound nature of physical sciences being a combination of two different subjects – physics and chemistry.

There is reduced integration of the physical sciences content with everyday knowledge in CAPS compared to NCS. There is also low-level integration between subjects and in fact, horizontal coherence is not a design consideration of the CAPS documents (UMALUSI, 2014: 56). The report notes the lack of availability of adequate resources for the experimental work for physical sciences, indicating that perhaps fewer than 5% of schools in the country are equipped well enough to implement CAPS experimental work, given the specialised nature of the equipment required for the classroom activities prescribed in CAPS (UMALUSI, 2014: 57).

While there is no significant change in the physical sciences content, there is significant change in "...terms of context, theoretical framing, and approach and

organising principle” (UMALUSI, 2014: 6). The report concludes that the CAPS curriculum is, therefore, not merely a repackaging of the NCS, but a new curriculum. The change towards content, curriculum driven, results-orientation in the teaching and learning environment in CAPS is probably the most significant change that is affecting teachers, as it influences their classroom practices and is a diversion from the NCS emphasis on a learner-centred approach in which an environment for meaning making and knowledge construction is envisaged. The reduced integration between subjects also provides a philosophical contradiction in physical sciences as the subject is a composite of two subjects: chemistry and physics. Even though this study focuses on implementation and not development, I am of the opinion that this shift from the constructivist approach of NCS and the lack of integration between subjects be given in-depth reconsideration by policymakers. Integration between subjects and a constructivist approach to classroom practice provides the strongest case for the development of critical thinking and other higher order cognitive abilities in the learner (Piburn *et al.*, 2000; Cohen, 1990). It seems that to improve matric results, policymakers have opted for what they consider a more efficient technical approach at the expense of current progressive trends such as constructivism. This might be the case where instead of policy influencing practice, practice has even had a greater effect on policy (Cohen, 1990). This shift may have long-term adverse effects on the development of the South African education system despite some possible short-term advantages. Curriculum implementation researchers are not limited to studying the obstacles or dynamics of the implementation fidelity of reforms but also evaluate the feasibility and effectiveness of the programme in providing what constitutes good education, as defined by existing or contemporary research findings.

2.9.2 Some changes in physical sciences in Curriculum Assessment Policy Statements

While the above summary on the CAPS curriculum are general, below I briefly highlight those aspects that I view as quite significant from physical sciences teachers' perspectives because they have direct influence on their classroom practices.

Changes in cognitive weighting

While the weighting has not changed for chemistry, the comprehension level has been emphasised in physics at the expense of analysis and application.

Table 2.4 below indicates the suggested weighting of cognitive levels for examinations and control tests for grades 10 to 12 in physical sciences.

Table 2.4: NCS weighting of cognitive levels (DBE, 2011: 143)

Cognitive level	Description	Paper 1 (physics)	Paper 2 (chemistry)
1	Recall	15	15
2	Comprehension	30	40
3	Analysis, application	45	35
4	Evaluation, synthesis	10	10

While the weighting has not changed for chemistry, the comprehension level has been emphasised in physics at the expense of analysis and application.

Table 2.5: CAPS weighting of cognitive (DBE, 2011: 144)

Cognitive level	Description	Paper 1	Paper 2 (chemistry)
1	Recall	15	15
2	Comprehension	35	40
3	Analysis, application	40	35
4	Evaluation, synthesis	10	10

Content weighting in grade 12: A comparison of the National Curriculum Statement and Curriculum Assessment and Policy Statements

There have been major changes in the content weighting in CAPS for grade 12 examinations. Major changes can be noted in topics such as mechanics where the mark weighting has increased from 45 to 63 marks. Some content that is taught in grade 11, such as Newton's Laws, are now being examined in grade 12 final

examinations. The content on waves, light and sound examined in grade 12 has also been drastically reduced with most of it being pushed into the grade 11 examination weighting. However, the topic on electricity and magnetism has seen an increase in weighting in grade 12. Furthermore, an important change in the chemistry paper is the amount of content on chemical change being examined with a dramatic increase from 40% of the paper to 56% with the content on acids and bases contributing to the bulk of this change (DBE, 2011).

2.9.5 Changes in the way examination questions are asked

In my experience as a physical sciences teacher, I identified some changes that influenced my practices directly. Some of the biggest changes made were in the way that the assessment questions in the final examinations in grade 12 are framed. In the CAPS curriculum, the questions do not provide hints to the learners. For example, an NCS question would be phrased as “using energy, intermolecular forces and structure, explain why Molecule A has a higher boiling point than Molecule B”, while CAPS would phrase the same question as “explain why Molecule A has a higher boiling point than Molecule B, using chemistry principles”. Thus, CAPS assessment requires learners to understand the science rather than to depend on hints in the examination in order to answer the questions successfully.

2.9.6 Changes in the grade 12 content in CAPS

In the physical sciences, changes have been made to content with the addition of sub-topics such as the Big Bang Theory under the Doppler Effect. In organic chemistry, there is also the inclusion of polymers, including the types of polymers, monomers, repeat units and the ways to distinguish between addition and condensation polymerisation. However, the most important change that has been made is probably the addition of the topic on acids and bases, including concepts such as neutralisation and titration. Teachers need to update their subject content knowledge (SCK), pedagogical content knowledge (PCK) and practical skills so that they can be competent enough to teach concepts and practical skills such as titration.

The changes include adjustments in the assessment of the cognitive levels in the final examinations as well as the wording in the questions. These changes in the curriculum should be understood by physical sciences teachers to be in different aspects

(cognitive levels, assessment strategies, content depth and breath as well as time allocations). In addition, for each aspect, teachers should be able to evaluate themselves on their shortcomings and their personal needs or the type of assistance they require to be compliant with the reforms. Therefore, platforms should be created where teachers can voice their concerns on how they can be assisted.

For the reforms to be fully implemented as envisaged by policymakers, physical sciences teachers must feel recognised as the ultimate agents of change without whose cooperation reform efforts would be futile. The changes in content, assessment strategies and content weighting may require some form of intervention strategies to enhance SCK, PCK and other knowledge domains. Currently, little research has been conducted to explore physical sciences teachers' concerns, attitudes and perceptions during this implementation process. Hence, these are not clearly understood. Further research could assist in exploring this. For example, whether the teachers feel as if they have sufficient knowledge to implement the changes and what kind of sense they are making of the reform directives. Once their concerns, practices and perspectives are understood, recommendations can be made to assist them in overcoming barriers to the changes and ongoing support structures can be developed.

Improvements in content knowledge domains, including pedagogical content knowledge

Reform implementation in science education certainly challenges teachers to improve their CK base (Grossman, 1990; Ramnarain & Fortus, 2013; Shulman, 1987). In South Africa, due to the unfair discrimination of the past, some teachers already find themselves with deficiencies in CK domains and a change in the curriculum often compounds these shortcomings. In recent decades, the research field of teacher CK has expanded since Shulman (1987) gave the first paper on the subject. Shulman's theoretical framework established that personal understanding of a subject alone was insufficient for a teacher to be able to teach it effectively (Grossman, 1990; Shulman, 1987; Wilson, Shulman & Richert, 1987). Since the early 1990s, various studies have expanded the categorisation of teachers' knowledge with CK and PCK being the main domains (Grossman, 1990; Shulman, 1997; Wilson *et al.*, 1987).

SCK is the background that teachers need to develop other knowledge domains, such as PCK. Teachers without sufficient SCK have misconceptions that have been identified, in some cases, as the source of children's difficulties in learning chemistry. Some researchers have called this chemistry content knowledge (CCK). For example, in teaching the concept of equilibrium, teachers have been found to harbour misconceptions about Le Chatelier's Principle, which is a key concept for students to understand equilibrium (Bridgart & Kemp, 1985; Torres, 2007). Insufficient CK is known to negatively influence teachers' capacity to develop CCK (Hashweh, 2005; Sanders, Borko & Lockard, 1993). This issue is usually magnified during the earlier years of new reforms.

Shulman (1997: 106) defined PCK as "...the most useful form of representation of those ideas and the most powerful analogies, illustrations, examples, explanations and demonstrations which represent and formulate the subject that make it comprehensible to others". With a good understanding of PCK, teachers should be able to simplify and comprehend those topics and concepts that are considered difficult to understand. In chemistry, teaching questions continue to be raised about chemistry pedagogical content knowledge (CPCK) concerning specific topics and concepts. Studies have been conducted on the relationship between CCK and CPCK (Hashweh, 2005; Sanders *et al.*, 1993) with most concluding that, to have sufficient CPCK, teachers need a strong foundational background in CCK. In some research, teachers' CPCK was found to be insufficient. For example, Roehrig and Kruse (2005) reported that high school teachers limit their explanation to macroscopic language when trying to explain microscopic phenomena to students.

In conclusion, curriculum reform implementation, among other aspects, may require teachers to update their knowledge bases, including their PCK, to align them with the demands of reform. Current reforms in physical sciences include new concepts and new topics, among them, the Big Bang Theory and polymers. Good support programmes and textbooks may also need to be developed to meet new demands.

2.10 Teachers' perspectives during science curriculum reforms

Teachers' perspectives and experiences in times of curriculum reforms have been the subject of study by researchers in recent years (Basson & Kriek, 2012; Dudu, 2014; Mansour *et al.*, 2014; Ramnarain & Fortus, 2013; Ryder, Banner & Homer, 2014). Teachers' perspectives, and how these impact their practices, need to be taken seriously if the implementation gap is to be closed. However, researchers may differ on what they prefer to focus on depending on the objectives of their studies. Researchers may focus on understanding teachers' perceptions, perspectives and experiences during reforms or on teachers' knowledge domains, curriculum knowledge and their professional developmental support during the reforms as well as teachers' general reception towards the changes. Teachers who changed because of a changing process viewed the changes as positive challenges rather than problems or threats (Bell & Gilbert, 1996).

Ryder *et al.* (2014) used interviews to investigate teachers' experiences and perspectives during major science curriculum reforms for 14-16 year olds in England. The sample consisted of 22 science teachers from 19 different schools in the third, fourth and fifth years of the Enactment and Impact of Science Education Reform (EISER). The study concluded that personal issues determined teachers' perspectives during times of reforms; workplace relation dynamics and external features such as educational policies not necessarily related to science (Ryder *et al.*, 2014). Furthermore, teachers' responses to curriculum reforms are influenced by their contexts, which may often contradict with the policy directives of the curriculum (Ryder *et al.*, 2014). They further suggested that curriculum innovations should provide educators with flexibility that permits them to adapt curriculum changes appropriately within their local contexts. Professional development strategies should assist teachers in developing an informed and reflective perspective on curriculum policy directives.

A study by El-deghaidy *et al.* (2015) on Saudi Arabian teachers' perspectives in the context of reforms focused on their perspectives on continuing professional development (CPD). They concluded that teachers had reservations about existent CPD practices as they regarded themselves as passive recipients of a pre-packed

programme. Effective CPD for science teachers is one that ensures that educators are collaborative and proactive as leaders of reform.

In a study report entitled *South African physical sciences teachers' perceptions on new content in a revised curriculum*, Ramnarain and Fortus (2013) used a mixed methods approach to investigate teachers' experiences and perceptions of the educational value of new topics in the NCS physical sciences. Their study concludes that though teachers positively endorsed the new topics, "...a substantial number of teachers had difficulty understanding concepts related to these topics, and this consequently compromised their PCK" (Ramnarain & Fortus, 2013: 12). The study did not find any significant association between teacher perceptions on the new topics and the location of the school, suggesting that teachers at suburban, city, rural and township schools all shared these perceptions on PCK deficiencies and uncertainties. They also discovered that teachers shared similar perceptions irrespective of educational qualifications (Ramnarain & Fortus, 2013). When knowledge is not regularly accessed, such as when planning lessons, it may eventually become difficult to access over time (Arzi & White, 2007: 223). However, even though teachers with at least undergraduate qualifications may forget SCK due to a lack of regular use over time, the authors did not elaborate on what undergraduate qualifications the teachers had. Was it in the physical sciences? Alternatively, was it in chemistry only or in physics only? Were they Bachelors of Science holders with or without education qualifications? I am of the opinion that this break down is important when analysing physical sciences teachers' qualifications as it is a composite of two subjects and it may shed more light on how teachers grapple with new topics during times of reforms. Ramnarain and Fortus (2013) further explored how these teacher perceptions influenced practices, reaching important conclusions. Uncertainties with SCK and PCK often enables teachers to be more teacher-centred, through which they regain their authority and can control class proceedings with little questioning from learners (Cohen, 1990).

In a study to investigate the readiness of physical sciences teachers to implement NCS, Basson and Kriek (2012), used a revised framework on teachers' behaviour as their theoretical basis. They used focus group interviews to explore teachers

experiences with NCS, questionnaires were used to explore their perspectives, beliefs and attitudes towards NC and surveys were used to assess teachers' knowledge on physics content. Basson and Kriek (2012) reported that most of the participants were generally receptive of NCS. However, many cited content overload and time constraints in the NCS as a challenge that needed to be addressed (Basson & Kriek, 2012). The study concludes that the majority of the teachers felt unprepared to teach some concepts such as electronics and conductors. Teachers expressed that the preparatory training was inadequate and could have been better organised with professional subject experts. It should also be continuous and prolonged (Basson & Kriek, 2012). The survey on teachers' content knowledge revealed that teachers lacked basic content knowledge on some physics topics (Basson & Kriek, 2012). The researchers cite various authors (Resnick, 1987; Leinhardt & Greeno, 1986; Wilson *et al.*, 1987) to emphasise the complex nature of the teaching and learning process, through the demands it places on teachers for the application of knowledge from different domains. The study revealed that participating physical sciences teachers were inadequately equipped with the right SCK and PCK to meet CAPS demands and were inadequately qualified. The majority (80%) of the participating physical sciences teachers were from three South African provinces (Gauteng, North West and Western Cape) and were teaching without any qualification in physics, chemistry or physical sciences. However, the study does not offer a breakdown of the other 20% in terms of what percentage had what qualifications.

It is reasonable to assume that a teacher who has a Bachelor degree in physics education may confront challenges in teaching chemistry topics and vice versa. In addition, from that 20% with some form of relevant qualification, it is possible they may not possess an education background and may have deficits in domains such as PCK or experimental skills. Future studies should go further in characterising physical sciences teacher qualifications, bearing in mind that the ideal physical sciences teacher should have chemistry and physics and an education background. In some schools where, if there are two teachers, one of whom majored in physics while the other majored in chemistry, they try to complement each other by ensuring that one teaches chemistry topics only and the other teaches physics only in accordance with their qualifications. However, in most schools this kind of arrangement is not in place or cannot be put in place. Thus, sometimes someone qualified to teach physics only

teaches chemistry or vice versa. Future research could characterise physical sciences teachers' qualifications more completely by determining whether they have education qualifications or not, whether they have chemistry and physics as majors (or at least a minor in the other) and if they are teaching chemistry and physics topics. Such information may shed more light on the preparedness of physical sciences teachers to implement the new curriculum and may enhance researchers' efforts to explore teachers' concerns and challenges during curriculum reforms.

Most of the studies cited above indicate that teachers are generally quite receptive of curriculum innovations, at least in the initial phases. However, oftentimes they express that preparations are inadequate. In most studies, teachers prefer continuous, prolonged professional development.

2.11 Research perspectives on CAPS implementation

A few years into the most recent curriculum reform implementation in South Africa, there have already been some interesting studies on CAPS (Basson & Kriek, 2012; Moodley, 2013; Nakedi, 2014; Ramatlapana & Makonye, 2013; Nkosi, 2014; UMALUSI, 2014; Adu & Ngibe, 2014; Riffel, 2015; Koopman, Le Grange & de Mink, 2016; Taylor & Cameron, 2016). Ramatlapana and Makonye (2013: 8) concluded that the CAPS curriculum is "quite prescriptive to the point of demanding uniformity in implementation across the nation". Subject topics and concepts to be taught are explicitly delimited, leaving no room for flexibility and no appreciable freedom for teachers. They pointed out that government officials enforce this uniformity and the prescriptions go as far as the textbooks that must be used. This, they further pointed out, encroaches on and restricts teachers' professional autonomy, even though the research is replete with findings confirming that teachers' professional autonomy enhances school efficiency and effectiveness (Ozturk, 2011).

Nevertheless, "...even as the South African education system is essentially centralised, decisions about what to teach and how are still within the purview of each classroom teacher..." (Jita & Mokhele, 2013: 134). Teachers must not be regarded as merely curriculum implementers but are also expected to make their own sense and meaning of the national curriculum guidelines (Jita & Mokhele, 2013). Winches (2007) concludes that a lack of teacher autonomy over curriculum reform implementation

reduces the creative profession of teaching for daily survival, with all of the associated negative connotations. Teachers are constantly making decisions in the classroom based on learners' needs, including their pre-concepts. Hence, a one-size-fits-all approach, which CAPS seems to suggest, is counterproductive. Ramatlapana and Makonye (2013) concluded that some teachers were not adhering to some of CAPS's academic demands and that the reasons for this non-adherence need further research. It is plausible to conclude that some teachers have concerns that are hampering their effective adherence to the CAPS curriculum.

Echoing the UMALUSI assessment that fewer than 5% of school laboratories are ready for CAPS implementation, Nkosi (2014) recommends, in a study of primary school teachers' experiences in implementing CAPS, that the responsible authorities make the provision of resources a high priority during curriculum reforms to mitigate teachers' concerns. Although the research by Nkosi (2014) focuses on primary school teachers, it also highlights general concerns and dynamics that have previously been obstacles to curriculum implementation in South Africa such as teacher workload, time constraints and a lack of sufficient resources.

In a doctoral thesis entitled *Physical science teachers' responses to curriculum challenges in South Africa: Pedagogical content knowledge focused case studies*, Nakedi (2014) used a multiple case study approach to comprehend how physical sciences teachers handle change during curriculum reforms. The major significance of this study is its suggestion for the possible application of learning for teaching through the participation model as a useful framework to enhance the PCK of science teachers. Such strategies aimed at transforming teachers' classroom practices are critical and relevant in the present circumstances as CAPS, at least in physical sciences, has several new content topics and a significant number of teachers may not necessarily be equipped with the appropriate PCK.

Investigating the readiness of schools to implement indigenous knowledge (IK) through the CAPS curriculum for meteorological sciences, Riffel (2015) conceptualises the need to employ an integrative, socio-economic and cultural context approach that uses a Dialogical Argumentation-based Instructional Model (DIAM) to integrate IK with classroom content in subjects such as natural sciences. This is

particularly done in grades eight and nine. The study concludes that embedding IK in science classes, through a DIAM intervention enhances learners' scientific worldview. This study may have been enriched by referring to the reduced integration between subjects in CAPS as well as the shift to a more technical, content driven curriculum as detailed by UMALUSI (2014). The suggestion to use argumentative dialogue in the class, though progressive and in accordance with recent trends that tend to foster sociocultural constructivist approaches, could be at odds with CAPS due to its shift towards a much more technical and traditional approach. Thus, teachers may find fewer opportunities to use approaches such as argumentative dialogues due to the restrictive nature of the new curriculum.

A study by Dudu (2014) used questionnaires and semi-structured interviews to investigate natural sciences teachers' roles during CAPS in the North West province of South Africa and concluded that there was a discrepancy between teachers' practices and their perspectives on those practices. While in questionnaires the majority of teachers claimed to use multiple learner-centred strategies, lesson observations revealed that teacher-centred traditional approaches largely dominated teacher practices (Dudu, 2014). Moodley (2013), in a dissertation submitted for a Master's degree (University of South Africa), used one primary school in KwaZulu-Natal as a case study to investigate the implementation of CAPS. The analysis of data from focus group interviews, document analysis and observations led Moodley (2013) to conclude that generally teachers were receptive of CAPS. Teachers who participated in the study reportedly cited clarity, structure, clear guidelines and timeframes as positive aspects of CAPS. The teachers, however, reported challenges related to quality and the amount of preparatory training, inadequate resources, increased workload and the impact of a rapid pace of the curriculum on teaching and learning (Moodley, 2013).

In a paper discussing and evaluating the current reforms in South Africa, Ramatlapana and Makonye (2013) used the theory of planned behaviour as their theoretical framework to investigate teacher autonomy under CAPS, compared to teacher autonomy under NCS. A survey questionnaire they conducted revealed that most participants (80.8%) exhibited positive attitudes towards implementing CAPS, mostly

because their cooperation with the reforms would assist their learners in passing. However, 34.6% of participants felt that the CAPS curriculum is too restrictive and left little room for individual teachers' creativity. Under CAPS, the department prescribes specific textbooks, even though 34.6% of the participating teachers stated that most of the textbooks were of poor quality and fell short of meeting their needs (Ramatlapanana & Makonye, 2013). The study reports that the majority of those who felt that CAPS was too restrictive despised the prescription of textbooks. It would be instructive to conduct a correlation study between teachers' preferred degree of autonomy and stages of concern. In their conclusion, Ramatlapanana and Makonye (2013) point out that the behaviours of teachers (probably stemming from their concerns and attitudes) are a function of a successful education process and that quality education can be enhanced by respecting and taking into consideration the issues teachers face during curriculum implementation. This author would furthermore add that the behaviours of teachers and their attitudes could only be understood through a careful study of their concerns. Although Ramatlapanana and Makonye (2013) carried out a partial study of teachers' concerns, a more structured and in-depth survey, exploring teachers' stages of concern followed by observations and interviews to explore the findings, could shed more light on teachers' concerns and improve efforts to characterise, understand, respect and respond to the issues affecting teachers. This could therefore enable policymakers to develop strategies promoting those practices and attitudes that are aligned with the reform.

Koopman *et al.* (2016) used phenomenology as their theoretical framework (Heidegger, 2002; Husserl, 1975) to capture the lived experiences of a physical sciences teacher during times of curriculum reforms. Although the study is based on the old NCS as it refers to pre-CAPS documents, the justification for using phenomenology as the theoretical framework is convincing and the methodological approach used could be effective in exploring physical sciences teachers' concerns, perspectives and practices during the times of reform implementation.

Other research studies have concluded that most physical sciences teachers lack an understanding of what inquiry-based science teaching implies, lack support resources and are not ready to meet the demands of the new reforms (Mokiwa, 2014; Tshiredo, 2013). Mokiwa (2014) uses a qualitative approach where interviews and observations

are conducted on participating physical sciences teachers to evaluate how they incorporate inquiry-based science in practice. Mokiwa (2014) and Tshiredo (2013) concur in observing that schools in rural areas and poorer districts of South Africa need special attention and monitoring as they lag behind in terms of readiness to implement current curriculum changes.

Most studies on physical sciences teachers during curriculum reforms indicate the lack of experimental skills, deficiencies in PCK and SCK, lack of adequately equipped laboratories and other resources as obstacles to implementation (Koopman *et al.*, 2016; UMALUSI, 2014). However, it is important to point out that these deficiencies are not new, as they were identified at the onset of NCS. These deficiencies are thus a recurrent challenge, especially considering that curriculum reform implies that teachers have deep and highly structured SCK that can be altered efficiently for the purposes of instruction (Sternberg & Horvath, 1995; Talbert, McLaughlin & Rowan, 1993).

A comprehension of curriculum documents and an understanding regarding curricular purposes and structures are essential for educators to draw upon to organise instruction and facilitate effective learning (Penuel *et al.*, 2014). Despite being arguably the most exhaustive document that examines, compares and unpacks the changes from NCS to CAPS, UMALUSI (2014) remains largely unreferenced by the majority of curriculum implementation researchers in South Africa. The reduced integration between subjects and the shift towards a technical, teacher-centred and result-oriented process in CAPS remains obscure to most researchers and yet these changes have a direct effect on teachers' practice and the implementation of the curriculum. Reducing teachers' role to simply implementers of a predetermined learning programme with little flexibility left to recognise the different contexts in which the teaching and learning process takes place may have adverse effects.

2.12 Pertinent curriculum implementation research and CBAM

Recently, teachers' concerns during curriculum implementation have been extensively studied (Al-Shabatat, 2014; Penuel *et al.*, 2014; Becker, 2011; Cruz, 2014; George, 2015; Jennings, 2015; Nawastheen *et al.*, 2014; Puteh, Salam & Jusoff, 2011; Çetinkaya, 2012; Lopez, 2015).

Becker (2011), in a doctoral dissertation (University of Florida, USA) employs a mixed methods approach and stages of concern survey questionnaire to investigate teachers' concerns regarding the implementation of an evidence-based educational curriculum in Florida in the United States. One of the aims was to examine how teachers' concerns contribute to or impede the adoption and sustainability of an educational reform. The SoCQ was followed by a qualitative stage in which interviews were used to determine the levels of use of the intervention. Becker (2011) concluded that teachers were not interested in implementing the innovation and most had discontinued the implementation of promising reforms because of personal concerns and managerial issues that those responsible for supervising the implementation had not identified or addressed.

Jennings (2015) used CBAM as the theoretical framework in a doctoral study focused on secondary mathematics teachers' concerns during curriculum reforms in Mississippi in the United States. The SoCQ, with two open-ended questions at the end, was conducted among 88 mathematics teachers in Mississippi secondary schools. The two open-ended questions served as the qualitative stage of a mixed methods approach. Although the impact of professional development on the stages of concern was not conclusively drawn, Jennings (2015) concludes that teachers with minimal professional development use the innovation less than teachers who have more professional development even though they also exhibited positive tendencies towards seeking more information that could enhance their implementation of the reforms. In addition, those with prior concentrated professional development revealed intense collaboration concerns, reflecting the desire to use collaboration to refine the reform implementation. Jennings' study suggests that good quality professional development focused on information and task management enhances curriculum reform implementation.

Al-Shabatat (2014) also used CBAM and a mixed methods approach in a study focused on teachers' stages of concerns for integrating an e-learning innovation in schools for gifted learners in Jordan. The findings revealed a general lack of interest in the reforms among participants who had relatively high self-concern scores and low task-concern scores. The results further revealed that females had serious concerns

towards the e-learning innovation and were more interested in the innovation than their male counterparts were.

Cruz (2014), in a doctoral thesis, also employed a mixed methods approach, consisting of CBAM instruments and interviews, concluding that teacher-leverage can have a positive influence on curriculum implementation. Identifying and equipping potential leaders among teachers can furthermore enhance reform implementation. Cruz (2014) suggested further research regarding the nature of coaching for change and shared leadership structures, practices and policies.

Using a qualitative approach and two of the three CBAM instruments, namely the levels of use and the interview protocol, a study focused on teachers' levels of use during curriculum reform in Sri Lanka was conducted with CBAM as the theoretical framework (Nawastheen *et al.*, 2014). The study sought to assess teachers' participation in the implementation of a reform called the "5E instructional model" which was an innovative approach to classroom instruction. From their findings, the authors concluded that many teachers were either non-users or at the initial stage of use of the model. Having observed the unsatisfactory level of use of the innovation, the researchers suggested the development of strategies that target those teachers who seem to have a low participation level or those who were not using the innovation at all. However, this researcher states that, to develop those strategies, the initial step would be to determine why those teachers are at such an initial stage of innovation or why some are not using the innovation. This may require a study that investigates their concerns. Having a clear understanding of teachers' concerns will thus facilitate the development of appropriate strategies.

2.13 Processing SoCQ data

Among the plethora of research articles, dissertations and theses using the stages of concern questionnaire on the international scene (Al-Shabatat, 2014; Becker, 2011; Cruz, 2014; George, 2015; Jennings, 2015; Nawastheen *et al.*, 2014; Puteh *et al.*, 2011; Çetinkaya, 2012; Lopez, 2015), there are issues that warrant special attention. Firstly, the analysis of SoCQ data warrants some attention and secondly the significance of the results from this analysis.

A possible source of misunderstanding (and likely confusion) in the use of the stages of concern questionnaire data are two types of data: raw scores and percentile scores. The recommended procedures to obtain the raw scores, convert the raw scores to percentile scores and constructing individual and group profiles are documented in the developers' manual (George *et al.*, 2006). The developers furthermore emphasise that the instrument validity studies were conducted using these percentiles to interpret concerns about the various innovations described and "...the percentiles proved to be representative of other innovations" (George *et al.*, 2006: 28). While most researchers follow the developers' recommendations to use percentile scores to construct relative intensity graphs (Becker, 2011; Cruz, 2014; George, 2015; Al-Shabatat, 2014), often some researchers used the raw scores (Çetinkaya, 2012; Lopes, 2015; Puteh *et al.*, 2011). While users may modify or make decisions deviant from the developers to improve the instrument, in such cases it might be prudent to justify such decisions and in some cases, seek permission from the developers. In the studies cited above (Çetinkaya, 2012; Lopes, 2015; Puteh, 2011) no justifications were provided, tempting a reader or reviewer to regard the decisions as erroneous.

The researchers recommend the use of raw score for statistical analysis because "...conversion to percentiles greatly affects the distribution of the scores, tending to make the distribution rectangular" (George *et al.*, 2006: 28). Al-Shabatat (2014) concludes significant differences by referring to profile graphs but no reference is made to any statistical analysis such as MANOVA, ANOVA or any p-values. Using a two-way between-groups analysis of variance (Two-Way ANOVA), Puteh *et al.* (2011) found no significant differences in raw scores according to school location or academic qualifications of the school managers but found significant differences among teachers in both case. However, they did not reveal at what level their p-values were set. Cruz (2014) (highest peak collaboration stage; doctoral thesis Arizona State University, USA) did not conduct any statistical analysis because of the small size of the study sample (8 participants).

Results from the stages of concern questionnaire should be regarded as working assumptions that in most cases researchers explore further using interviews and observations and any such qualitative methods. "Erroneous" assumptions because of such possible reasons cited above may not be enough to invalidate entire studies but

they would certainly offer unexpected challenges when researchers further explore these assumptions.

2.14 Conclusions

Chapter two focused on the current literature on curriculum reform implementation in education. Recent curriculum innovations in South Africa, starting with C2005 until the recent CAPS, were analysed. An effort was also made to discuss the different perspectives and theories on curriculum implementation from local and international perspectives. Teachers' central role as agents of change in the reforms were further discussed. In addition, CBAM, as a conceptual framework, was analysed from its main objective to seek an understanding of teachers' concerns during programme implementation.

Other conceptual frameworks, such as teachers' enactment zones, were discussed and evaluated with regard to their contributions to enhancing the reform process. The obstacles in reform implementation were further discussed. Throughout the literature review, I noticed that some recent international studies on curriculum implementation use CBAM as a theoretical framework to investigate teachers' concerns during periods of curriculum reform. Most of these studies also seem to recognise the inadequacy of using only the qualitative or the quantitative approach to respond to the complex nature of the research questions surrounding curriculum implementation. Hence, the use of the mixed methods approach in such studies is prevalent. Although there are studies that investigated curriculum reforms and teachers' role during innovations in South Africa, there is a scarcity when it comes to in-depth studies and analyses of teachers' concerns during curriculum reform implementation. In the next chapter, the methodology and research strategy for this research will be discussed.

Chapter Three: Research methodology

3.1 Introduction

In the previous chapter, a literature study was conducted to explore curriculum reform and implementation in post-apartheid South Africa. The role that teachers play as agents of change during the implementation process was emphasised as their perspectives and concerns were considered pivotal for the success of any reform implementation. Teachers' perspectives were found to explain some of their practices during reforms. There is a myriad of international studies that have incorporated the concerns-based adoption model (CBAM) and mixed method approaches to comprehend the complex nature of curriculum implementation (Al-Shabatat, 2014; Penuel *et al.*, 2014; Becker, 2011; Cruz, 2014; George, 2015; Jennings, 2015; Nawastheen, Puteh & Meerah, 2014; Çetinkaya, 2012). However, not enough research uses CBAM and mixed methods to examine the issue of curriculum implementation in the South African context. This study uses a stages of concern questionnaire (one of the CBAM instruments) in the initial quantitative phase to formulate assumptions that were explored further through the qualitative phase.

This chapter discusses the research methodology, methods and designs appropriate to the problem and includes a description of the population and sample. The philosophical basis of the research and the use of mixed methods are justified. The research strategy and the topology of the mixed methods are briefly presented and reviewed. In addition, justifications for the decisions made are given. The instruments used are discussed including their validity and reliability. The methods and procedures of data collection and analysis are described. A description of the pilot study conducted is also presented. Overall, in this chapter I attempt to provide adequate information to enable other experienced investigators to replicate this study.

3.1.1 Overview of the research design and methodology

Table 3.1 below gives a summary of the research design and methodology. The table highlights the important characteristics of the methodology such as the methodological approach and data collection instruments. The details are discussed in the rest of the chapter.

Table 3.1: An outline of the research methodology and design

Feature	Description/Meaning
Methodological approach	Mixed methods approach (MMA)
Worldview	Pragmatism
Theoretical framework	Concerns-based adoption model (CBAM)
Research design	Explanatory sequential design (SES)
Emphasis	Equal emphasis between qualitative and quantitative
Pilot study	Two schools and four teachers
Selection of site and participants	Quantitative: Grade 10, 11 and 12 physical sciences teachers in the Motheo district of the Free State. Qualitative: 5 selected participants from the main sample
Data collection methods	Quantitative: Questionnaires: Stages of concern, demographic and open-ended questionnaire Qualitative: Classroom observations, interviews, field notes, research journal
Data documentation	<ul style="list-style-type: none"> • Audio recordings • Video recordings • Transcriptions • Research journal • Field notes
Data mixing method	Connecting between data collection and data analysis
Data analysis	<ul style="list-style-type: none"> • Quantitative (SPSS) • Profile interpretation • Qualitative
Ethical considerations	<ul style="list-style-type: none"> • Informed participant consent • Voluntary participation • Confidentiality of participants
Quality criteria of the study	<ul style="list-style-type: none"> • Credibility • Transferability • Dependability • Confirmability • Reliability • Validity

3.2 Research paradigm

To ensure a strong research design, I needed to select a research paradigm that is aligned with my worldview and beliefs regarding the nature of reality (Mills, Bonner & Francis, 2006: 2). A researcher's paradigm can be defined as their worldview (Rocco *et al.*, 2003) or a pattern, structure and framework or system of scientific and academic ideas, values and assumptions (Olsen, Lodwick & Dunlop, 1992: 16). Alternatively, it can also be defined as a basic set of beliefs that guide actions (Guba, 1990: 17) or a general philosophical orientation about the world and the nature of research that a researcher brings to a study (Creswell & Plano Clark, 2011; Creswell, 2013). According to Morgan (2007), it can also refer to epistemological stances that guide a researcher in the research process. However, to Kuhn (1962), who coined the term, a paradigm denotes a framework that provides a group of researchers with a convenient model for examining problems and finding solutions.

Thus, a paradigm forms the philosophical basis on which enquirers draw from in the way they think and ask questions, design their approaches to solve problems and write reports on their findings. Morgan (2007) reviews the four commonly used definitions of paradigms: firstly, as worldviews, secondly as epistemological stances that guide a researcher, thirdly as model examples that researchers use in the research process and lastly as shared beliefs in a research field. The many definitions of paradigms are often confusing to novice researchers and may seem contradictory but Morgan (2007) posits that these definitions are only different in their degree of generality. Morgan (2007: 51) further chooses to synthesise them into one encompassing definition, namely, a paradigm is a shared belief system that influences the kind of knowledge that researchers seek and how they interpret the evidence they collect. The definition of paradigms *as epistemological stances that guide researchers* is the most commonly used among researchers despite being quite broad. However, Morgan (2007) appreciates the advantages of using this definition because of its reliance on well-known elements from philosophy of knowledge, ontology, epistemology and methodology.

Despite their impact on social science research, paradigms remain largely "obscure" and they need to be stated (Creswell, 2009). Some of the common paradigms

available to researchers include positivism, post-positivism, interpretivism, realism and pragmatism.

The pragmatic approach is the most appropriate to describe the research paradigm for this study. Below I provide a summary of what a pragmatic approach entails and I provide a rationale for its choice in this study.

3.2.1 Pragmatism as the research paradigm for this study

The complex nature of the research question for this study led me to consider appropriate approaches and methods to respond to the unknowns. The approaches and methods had to align with my worldview and epistemological stances. The pragmatic approach emerged as the unique paradigm that could articulate my worldview and the appropriate methods and approaches to respond to the research question and the sub-research questions.

Pragmatism as a research worldview emerged in the 1990s through research carried out by Piece, Dewey and others (Cherryholmes, 1992). In recent times, other researchers have made significant contributions to present the case for pragmatism as a recognised useful worldview (Rorty, 2000; Murphy, 1990; Patton, 2002; Cherryholmes, 1992; Johnson & Onwuegbuzie, 2006; Morgan, 2007; Maxcy, 2003; Tashakkori & Teddlie, 2010; Cherryholmes, 1992; Rossman & Wilson, 1995). Pragmatists posit that knowledge claims arise from actions, situations and consequences rather than from certain predetermined conditions (Johnson *et al.*, 2006). They tend to emphasise “what works” and therefore place greater importance on the problem rather than on methods. For pragmatists, all approaches or methods are possible options for use in solving and understanding the problem (Rossman & Wilson, 1995). Thus, for this study, qualitative and quantitative approaches were used as they would assist me to respond to different sub-research questions.

Because of its practical approach to problem solving, pragmatism tends to be the apparent paradigm for mixed methods (Tashakkori & Teddlie, 2010). Mixed method research bases the inquiry on the assumption that collecting diverse types of data and pluralistic approaches offer the best possible way of understanding and solving complex social problems and deriving knowledge (Johnson & Onwuegbuzie, 2006;

Tashakkori & Teddlie, 2010). Pragmatism is not committed to any system of philosophy or reality. This obviously appeals to mixed methods researchers as they liberally draw from quantitative and qualitative approaches to solve a problem. Individuals are free to choose from different methods, procedures and techniques as they see fit.

For me truth is what works and truth is not necessarily based on the dualism between the mind and a reality completely independent of the mind (Johnson & Onwuegbuzie, 2006; Morgan, 2007; Maxcy, 2003) and these stances were especially important considering the research question. Approaches such as the qualitative and quantitative approaches are not viewed from a dualistic view but they are a continuum. For pragmatists, research occurs in different political, social, historical and economic contexts, leading to pragmatists having a post-modernism bias with all its consequences concerning social justice and political aims. They tend to think less about the philosophy, reality and laws of nature and just want to focus on solving the problem (Morgan, 2007).

Thus, for this research, this pragmatic approach permitted me to use multiple approaches, different methods and techniques as I best found fit to explore and understand teachers' perspectives, concerns and practices during the implementation of the physical sciences CAPS curriculum in South Africa. As I used a multiple pragmatic approach to respond to the sub-research questions in this study, it is important to give a brief outline of the theoretical lens that may be useful during different phases of the study.

3.2.2 Quantitative approach (post-positivism)

The first phase of this study sought to respond to questions two, three and four. A quantitative approach is appropriate to respond to the "what" of the phenomena and to questions seeking to understand relationships between variables. While I intended to determine what common concerns physical sciences teachers were experiencing during CAPS reforms – i.e. questions three and four – I sought to understand the relationships between these concerns, educational qualifications and teachers' years of experience.

The quantitative approach is sometimes referred to as scientific research or post-positivist research. Post-positivism refers to thinking beyond positivism, which is the notion that absolute truth exists and can be found (Phillips & Burbules, 2000) while recognising that we cannot be completely positive about our claims of knowledge when enquiring about human behaviour and human actions. Nineteenth century writers such as Comte and Locke made significant contributions to the development of post-positivism (Smith, 1983).

Post-positivists seek to determine causes and effects and the relationship between them, for example issues examined in experiments (Creswell, 2014). For example, in this study I sought to determine existent relationships between teachers' concerns, their educational qualification and years of teaching experience. Positivism is reductionist in that it intends to reduce seemingly large ideas into small, discrete sets of ideas to test, such as the variables that constitute hypotheses and sub-research questions. For this study, sub-research questions three and four were converted into testable hypotheses. According to Creswell (2013), the knowledge that develops through a post-positivist approach to research is based on careful observation and measurement of the objective reality that exists in a particular locality. Developing numeric measures of observations and studying the behaviour of individuals becomes significant to post-positivists. Laws and theories that govern the world need to be verified and refined to better understand the world. A positivist would start with a theory, collect data that either supports or refutes the theory and then make necessary revisions before conducting further tests (Creswell, 2013).

Phillips and Burbules (2000) developed the following key assumptions that post-positivism makes:

1. Absolute truth about knowledge can never be reached. Research evidence is always imperfect and fallible.
2. Research is the process of making claims and then refining them or abandoning some claims for those other claims that seem to be better supported by the existing data and evidence.
3. Data, evidence and rational considerations shape knowledge. The researcher collects information on instruments based on measures completed by participants or by observations recorded by the researcher.

4. Research seeks to develop relevant true statements that explain the situation of concern. Researchers advance the relations among variables and develop this in terms of questions or hypotheses.
5. Post-positivists emphasise being objective as an essential part of competent research. Methods and conclusions should be examined for bias. Standards of validity and reliability are considered important in quantitative research.

Thus, in this initial phase a validated instrument (stages of concern questionnaire) was used to collect data, which were processed using quantitative analysis software and analytical procedures carried out to test hypotheses.

Despite the rigorous nature of quantitative approaches, they have their limitations and in this study, these limitations were two-fold. Firstly, the results were tentative and should not be accepted as final (George *et al.*, 2013). Secondly, a quantitative approach cannot satisfactorily respond to some questions such as questions one, five and six, which focused on the how and why of the phenomena (Creswell, 2009). To verify the tentative assumptions from the quantitative phase and to respond to questions one, five and six, a different approach was necessary.

3.2.3 Qualitative approach (interpretive/constructivist)

The aim of qualitative research is to understand complex psycho-social issues and is most useful for responding to humanistic “why” and “how” questions as the researcher engages in an inductive process of organising data into categories and patterns (Creswell, 2013).

Contrary to quantitative research, which focuses on cause and effect, qualitative research is useful for exploring and comprehending a central phenomenon and the way people make sense of their experiences in the world (Creswell, 2009). In light of my need to explore teachers’ perspectives during the implementation of the CAPS curriculum, a qualitative approach was the obvious choice, especially in attempting to explain some findings from the quantitative phase and searching for responses to some questions that the quantitative approach could only partially answer or falls short of comprehensively answering.

Questions one, five and six concerned the why and how of teachers' perspectives and practices and therefore qualitative approaches were more appropriate to use in the second phase of the study. Observations, interviews, data analysis and field notes were the methods of qualitative data collection.

Bogdan and Biklen (2009) outline certain attributes involved in qualitative research:

1. Data is descriptive (field notes, interview transcripts)
2. Analysis is inductive
3. Data is collected in a natural setting such as in a classroom
4. Data is seldom reduced to numbers
5. The aim is to comprehend basic social processes

The flexible nature of qualitative research was found more suitable to respond to questions one, five and six because it permits a natural interaction between the researchers and the participants. Though I had a general structure for the semi-structured interviews, during the interview itself, I was flexible to follow a certain line of questioning depending on the response from a participant. The use of open-ended questions in interviews permits the participants to voice their own experiences, perspectives and concerns about the process of curriculum implementation in such a way that it enhances better understanding of the phenomenon.

Classroom observations permitted me to experience first-hand the natural setting in which teachers' perspectives, concerns and experiences are shaped. The use of observations and interviews allowed me to verify how aligned teachers' perspectives were to their classroom practices and to comprehend how these perspectives can explain their practices during times of curriculum reforms.

3.2.4 Mixed methods research

While questions two, three and four could only be responded to through quantitative approaches, questions one and question five required qualitative approaches. Question six required an integration of qualitative and quantitative approaches. This meant that for this study, neither the quantitative approach nor the qualitative approach alone could respond to all the sub-research questions satisfactorily and this led to the decision to use a mixed methods approach for this study. Mixed methods research

involves collecting and integrating qualitative and quantitative research in a single study (Creswell, 2013). The decision to use mixed methods meant more decisions regarding various features of the mixed methods approach.

Characterising this study using Onwuegbuzie and Comb's (2010) 13 criteria framework

I am of the opinion that the decisions that a mixed methods researcher makes in meeting the 13-criteria framework suggested by Onwuegbuzie and Comb (2010) are an important puzzle in the use of the complex approach and can assist any researcher to design their research study appropriately. It is plausible that not all 13 criteria may be applicable to all mixed methods research studies. Below, I describe some of the decisions that I made from this framework for this present mixed methods study.

The rationale or purpose for conducting this study using the mixed methods approach is complementarity. The qualitative or the quantitative methods alone are insufficient to respond satisfactorily to the complex research question on curriculum implementation in this study. While qualitative and quantitative methods each have their advantages and disadvantages, a mixed method approach takes advantage of the strength of these two methods resulting in the two complimenting each other to produce a more effective method. Therefore, the mixed method is more relevant to this research study to better triangulate and corroborate data gathered from teachers.

The philosophy underpinning this mixed methods approach is pragmatism, a decision that has been discussed elsewhere in this chapter (section 3.2.1). In this study, quantitative and qualitative data were collected and analysed. This mixed methods study is a sequential explanatory design as quantitative data collection is conducted first followed by the qualitative data collection. The quantitative and the qualitative phases were given equal priority in this study. The analyses were linked directly to the mixed research design for the study (Teddlie & Tashakkori, 2009), making it a design-based link when the decision was made for the ninth criteria.

This is a fixed or prior mixed method design as the use of quantitative and qualitative methods is decided beforehand. The emergent mixed method design is when a

second approach (either quantitative or qualitative) is only considered when the research is already underway because either approach alone is found inadequate to meet the objectives of the study (Morse & Niehaus, 2009). In table 3.2 below, I summarise the framework and the decisions that I made.

Table 3.2: Criteria framework by Onwuegbuzie and Comb (2010)

Table	Criterion	Criteria manifestation in this study
1	Rationale/purpose of conducting mixed methods analysis	Complementarity
2	Philosophy underpinning	Pragmatism
3	Data types	Quantitative and qualitative
4	Data analysis	Quantitative and qualitative
5	Time sequence of MM	Sequential explanatory design (quantitative followed by qualitative)
6	Level of interaction between quantitative and qualitative analyses	Phase 1 data analysis informs the analysis at phase 2 (Teddlie & Tashakkori, 2009)
7	Priority of analytical components	Equal weight
8	Number of analytical phases	Three: SoC questionnaires: (Quantitative) <ul style="list-style-type: none"> • Interviews and observation data: (Qualitative)
9	Link to other design components	Design-based
10	Phase of the research process when all analysis decisions are made	Priori
11	Type of generalisation	<ul style="list-style-type: none"> • Naturalistic • External
12	Analysis orientation	Variable-oriented analyses and case-oriented analyses
13	Cross-over nature of analysis	Minimal

The eleventh criterion refers to the type of generalisations pertinent to the mixed methods analysis design and some researchers have identified this criterion as the *fundamental principle of mixed methods data analysis* (Stake, 2005; Stake & Trumbull, 1982). Results of this study can be generalised in two ways depending on the reader's role or interests in the current reform efforts in South Africa, i.e. naturalistic generalisation and external generalisation.

For physical sciences teachers reading the report on this study, a naturalistic generalisation is the lens through which they are expected to generalise the findings. A naturalistic generalisation means that readers of the findings will understand it from the vantage point of their own personal experiences (Stake, 2005; Stake & Trumbull, 1982). External generalisation is when broader generalisations, inferences or predictions on data are obtained from a representative statistical sample to the population from which the sample was drawn (Onwuegbuzie, Johnson & Collins, 2009).

The nature of the initial sampling followed by the case selection of the sub-sample for the qualitative phase allows for such broad generalisations that permit the final report to assist government officials, policymakers and other stakeholders in developing strategies that may enhance the present curriculum implementation.

This study uses a combination of variable-oriented analyses and case-oriented analyses. The quantitative phase required a variable-oriented analysis that was used to identify relationships among construct variables with a tendency to yield external generalisations of the findings to the broader South African context. The qualitative phase focused on five cases that were analysed in greater depth. The meanings, experiences and perspectives of these individuals in their contexts were interpreted (Onwuegbuzie *et al.*, 2009).

Explanatory sequential design

The type of mixed method research approach that I used for this study is called the sequential explanatory strategy (SES). In SES, one dataset builds on the results from

the other. This study therefore consists of two phases, a post-positivist initial phase where data were collected using a stages of concern questionnaire followed by an interpretive qualitative phase in which I used observations, document analysis and interviews to explore the findings from the quantitative phase further.

The qualitative data were used to explain the mechanisms underlying the quantitative results of the first phase in more depth as well as make them easier to understand (Creswell & Clark, 2007). Greene, Caracelli and Graham (1989) identify five purposes for conducting mixed methods research, namely triangulation, complementarity, development, initiation and expansion. The purpose of this mixed method study is complementarity, in which findings from the qualitative phase were used to elaborate, illustrate, enhance and clarify the findings from the initial quantitative phase (Combs & Onwuegbuzie, 2010).

The quantitative method enabled me to respond to some of the sub-research questions such as question two, three and four, which probed the “what” on teachers’ concerns and the relationship of these concerns to teachers’ levels of education and years of experience during the CAPS curriculum implementation. The qualitative phase sought to specify these concerns and explore teachers’ individual perspectives, and these were used to explain teachers’ classroom decisions during the implementation of the CAPS curriculum.

3.3 Sub-research questions alignment with methodological approaches

The table below identifies the approaches to align the research questions with the quantitative or the qualitative approach.

Table 3.3: Alignment of the sub-research questions with the methodological approaches

Research phase	Research phase questions	Participants	Type of data collection	Instruments	Data obtained	Data analysis
1	Q2, Q3, Q4,	Grade 10, 11 & 12 physical sciences teachers in Motheo (81)	Quantitative	✓ SoC	Questionnaire data Concerns Demographic data	Raw scores Raw score means Individual percentile scores Relative intensity graphs MANOVA (Q3 & 4)
2	Q1, Q5, Q6 Q1, Q5, Q6,	Sub-sample from above (five)	Qualitative Qualitative	Observations Document analysis Semi-structured interviews	Observation field notes, video recordings Interview audio recordings, transcribed	✓ Coding ✓ categorising

3.4 Sampling procedures

In this study, I made sampling decisions that I considered appropriate in enabling me to understand physical sciences teachers' perspectives and practices in times of curriculum reforms. Below, I describe the sampling procedures that include the setting of the study, the selection of the schools and the selection of the participants.

3.4.1 Setting of the study

This study was conducted in the Motheo district of the Free State. The Free State is one of the nine provinces of the Republic of South Africa.



Figure 3.1: Map of the districts of the Free State (extracted from <http://www.businessinsa.com/>)

The Free State is the most central province in terms of geographical location and it hosts the judicial capital city of South Africa, namely Bloemfontein. The province is demarcated into five districts, one of which is the Motheo district (see fig 3.1 above). Although it is the smallest district in terms of geographical area, Motheo is the largest and the most diverse in terms of population constitution.

The capital city of the province, Bloemfontein, falls under the Motheo district. The district schools are from various backgrounds, almost representative of the country's

diversity, including city, rural and location schools. I selected the Motheo district because of various reasons. Firstly, I had had first-hand experience of teaching in the district and it was through my experiences that I was motivated to identify the problem and the need to study teachers' perspectives and concerns during times of curriculum reforms. Of the few research studies on curriculum reforms, especially focusing on teachers' perspectives and practices in South Africa, I could not find one that was based on physical sciences teachers in the Free State or in the Motheo district. The diversity of the schools in the Motheo district in terms of location and ethnicity made it more representative of South Africa compared to any of the other four districts in the province.

3.4.2 Selection of schools

All schools offering physical sciences in the Motheo district were part of this study. The list of schools that was requested and received from Motheo district departmental education authorities consisted of 82 such schools.

3.4.3 Selection participants

The participants for the quantitative survey questionnaire were all grade 10 to 12 physical sciences teachers in the Motheo district whose teaching load consisted of approximately 50% physical sciences periods. The number of such teachers in the Motheo district as of February 2016 was 120 teachers from the 82 schools. Of the visited schools, 96 physical sciences teachers from 69 schools consented to participating in the research and were handed the questionnaires, 85 of these teachers completed the questionnaires (including the four pilot study participants) which were collected from the schools a day or a couple of days after dropping them off. This represents a response rate of 88.5%.

The qualitative phase participant selection was conducted after partial analysis of the quantitative results. Five participants were selected based on the relative intensity profiles of the concerns, gender representation and educational qualifications. For the qualitative phase, which included observations, interviews and document analysis, five participants were selected for the observations, interviews and document analysis.

3.5 Pilot study

Pilot studies are used for pre-testing research instruments and as trial runs in preparation for a major study (Simon, 2011; van Teijlingen & Hundley, 2001). Pilot studies enable the development and testing of the adequacy of instruments in measuring what they intend to measure as well as assessing the feasibility of the full study and establishing whether the sample technique is effective. A pilot study enables the researcher to assess the proposed data analysis techniques and trains the researcher in as many elements of the research as possible (van Teijlingen & Hundley, 2001). The general aims of the pilot study were three-fold. Firstly, to structure and adapt the stages of concern questionnaire, secondly to structure effective interview and observation protocols to ensure that they generate the intended data and, thirdly, to enhance my personal experience and increase my efficacy in utilising the techniques involved. The pilot study also enabled me to evaluate different data analysis procedures so that in the end I settled on the best procedure and avoided possible pitfalls during the actual data collection.

Four high schools in the Motheo district of the Free State were selected for the pilot study. After seeking the relevant permission from the principals (Appendix B1), consent forms were given to the teachers who agreed to be part of the study. The purpose of the research study was explained to the participants beforehand. Data analysis on the four questionnaires was carried out using the statistical package for social sciences (SPSS) software. An interpretation of the peak stage scores and a profile interpretation were carried out using the graphical profile analysis and the SoCQ percentile data provided by the developers (George *et al.*, 2006).

Classroom observations were video recorded and field notes were taken. The interviews were audio recorded. Transcriptions of the video recordings and audio recordings were done using a word processor. In addition, these were subsequently coded into categories and subcategories. The experiences with the pilot study led to some adjustments of the instruments. Firstly, it was noted that participants would need more than the 15 minutes recommended by the developers to complete the survey questionnaire. Thus, the time to complete the survey was adjusted to approximately 30 minutes. Secondly, I discovered that teachers are mostly too busy to complete the survey on the same day I visit the schools. Thus, I decided that I would leave the

questionnaire but have them complete the consent form and make a follow up visit the following day to collect completed questionnaires. Before the follow up the next day, I would use their telephone number (in cases where they provided their telephone numbers) on the signed consent form to confirm if they were ready to submit the completed survey questionnaire.

Lesson observations during the pilot study resulted in further adjustments. Firstly, it required flexibility as sometimes a teacher's schedule could be affected by workshops, departmental visits and even a teacher's personal life. Thus, it required psychological preparation for such eventualities and having another teacher visit as an alternative plan for the day.

Observations for experiments offered more challenges than lesson observations for various reasons. Firstly, they required more preparation time for the teachers; hence, they were more likely to be cancelled or postponed, secondly, generally a physical sciences teacher has less experimental classes than class lessons and thirdly, class experiments could be cancelled for the same reasons as class lessons, as cited above.

3.6 Data collection: Methods and procedures

To collect data, I used the stages of concern questionnaire, an open-ended questionnaire consisting of six questions, document analysis, observations of classes including practical experiments and semi-structured interviews. Below, I describe in detail each of these data collection methods and procedures.

3.6.1 Stages of concern questionnaire

Overview

The first phase of this study is quantitative and involved adapting, administering and analysing Hall and Hord's CBAM stages of concern (SoC) instrument. Copyright permission for using the stages of concern instrument, in line with intellectual property rights, was sought and obtained (see appendix C1). The main objectives of this first stage were to respond to sub-research question two as well as to establish the relationship between teachers' stages of concern and factors such as teachers' years

of experience and level of educational qualifications. In the process, the proposed hypotheses were subsequently tested and verified. This initial stage also prepared for the second phase in which teachers' perspectives and concerns were further explored through individual observations and semi-structured interviews.

The SoC questionnaire

Table 3.4: Expressions of concern about an innovation (George *et al.*, 2013:4)

	Stage of concern	Expressions of concern
Impact	Refocusing	The individual focuses on exploring ways to reap more universal benefits from the innovation.
	Collaboration	The individual focuses on coordinating and cooperating with others regarding using the innovation.
	Consequences	The individual focuses on the innovation's impact on students.
Task	Management	Issues related to efficiency, organising, managing and scheduling dominate.
Self	Personal	The individual is uncertain about the demands of the innovation, his/her adequacy to meet those demands and/or his/her role with the innovation.
	Informational	The individual indicates a general awareness of the innovation and interest in learning more details about it.
	Unconcerned	The individual indicates little concern about or involvement with the innovation.

These expressions are broad and general. The observations and interviews conducted during the qualitative phase of this study sought to specify these expressions in the five case-selected physical sciences teachers. For example, for a participant showing high relative intensity on the management concerns the interview sought to understand what specific concerns about efficiency, organising, managing and scheduling the participant had and what could be the possible causes of those concerns. In table 3.5 below, the typical questions related to each stage are shown. However, in the questionnaire the questions are placed according to the stages.

Table 3.5 Examples of stages of concern typical questions

	Stages of concern	Typical question
SoC6	Refocusing	I now know of some other approaches that might work better.
SoC5	Collaboration	I would like to help other teachers (faculty) in their use of CAPS (the innovation).
SoC4	Consequences	I am concerned about how CAPS (the innovation) affects learners (students).
SoC3	Management	I am concerned about not having enough time to organise myself each day.
SoC2	Personal	I would like to know how my teaching or administration is supposed to change.
SoC1	Informational	I have a very limited knowledge of CAPS (the innovation).
SoC0	Unconcerned	I am preoccupied with things other than CAPS (the innovation).

As per signed agreement with the developers of the questionnaire, no major modifications were made to it. Where the original questionnaire uses the words in brackets, for this study questionnaire I replaced them with the preceding words. For example, I replaced the phrase “the innovation” with the word “CAPS”, the word “students” with the word “learners” and used the word “teachers” where the original questionnaire used the word “faculty”. Thus, the changes that were made included using words to convey the same meaning as the original words or phrases that physical sciences teachers in the Motheo district would easily understand without changing the essence of the questionnaire.

Completing the stages of concern questionnaire

The questionnaire (Appendix C2) had six pages including a cover page, which spelt out the purpose of the questionnaire, instructions and examples on how to complete it. Section A was the stages of concerns questionnaire, which consisted of 35 questions. Each question has a Likert-type scale from 0 to 7. From those 35 questions,

five of them belonged to each stage (unconcerned [stage 0], personal [stage 1], informational [stage 2], management [stage 3], consequences [stage 4], collaboration [stage 5] and refocusing [stage 6]). However, these were not grouped according to those stages so participants did not know which stage of concern any particular question belonged to. Participants would circle 7 if the statement was very true to them at the time, if the statement was somewhat true they would circle 4, if the statement was irrelevant they would circle 1 and if the statement was irrelevant or outdated to the participant then they would circle 0.

Section B, whose data were collected as nominal, consisted of demographic data relating to the participants. This data consisted of level of education and number of years of teaching experience, how many years they had been teaching under CAPS, how many years of teaching experience they had overall and if they taught chemistry or physics topics or if they taught both.

3.6.1.4 Open-ended questionnaire

Demographic data can provide useful context in the interpretation of stages of concern questionnaire data (George *et al.*, 2006). For this study, an open ended-questionnaire under a subheading 'Section B' accompanied the stages of concern questionnaire. This open-ended questionnaire consisted of six questions that sought respondent's data on their gender, years of teaching experience, years of teaching experience under CAPS, highest level of education and what the respondents had majored in during their tertiary education. Options were provided below the open-ended questions and respondents would select their most appropriate answer by ticking on the options.

3.6.1.5 Questionnaire distribution

As the open-ended question formed section B of the stages of concern questionnaire, the document was distributed as one questionnaire. Using a GPS, the list of schools offering physical sciences in the Motheo district, my ethical clearance letter from the University of the Free State, an approval letter from the Free State Department of Education and another letter from the Free State Department of Education informing the district office of my research, I set out to distribute the questionnaires. The routine would involve making a list of the schools I planned to visit each day, arrive at a school

and request to see the principal or the deputy principal. I would introduce myself and present my permission letters.

Understandably, most principals did not want teachers to be disturbed during lesson times. However, in some cases when I could not see the physical sciences teachers in person, I would request to leave the questionnaire(s), which contained instructions on how to complete it together with the consent form for the physical sciences teacher(s). In other cases, the principals would call for the teacher, to whom I would quickly introduce myself and give a quick orientation about my research and on completing the questionnaire. If they consented, I would ask them to complete the consent form then I would leave them with the survey questionnaire and arrange to come back the following day to collect the completed questionnaire. If the following day fell on a school day, I would visit those schools to collect the completed questionnaires. A typical day would involve dropping questionnaires in some schools and collecting completed questionnaires in others.

However, this procedure was not without challenges. Some principals could not allow me to do the research in their schools and gave excuses, such as in one case where the principal insisted that their physical sciences teacher would not be of much help to my research. Some teachers simply declined to participate. Others would consent, accept the questionnaire but fail to complete it or would claim to have completely forgotten about it or have misplaced it. After a month, I had visited 77 of the 82 schools offering physical sciences in the Motheo district and had distributed 96 questionnaires to those who had consented. From those 96 questionnaires, I collected 81 completed questionnaires (excluding four that had been used for the pilot study) from 65 of the 82 schools offering physical sciences in Motheo district. This represents a response rate of 88.5%.

3.6.2 Overview of the qualitative phase

The qualitative phase aimed at exploring teachers' concerns, perceptions and perspectives during the implementation of CAPS. Findings from the initial quantitative phase were used to inform this second phase. Necessary adjustments to this phase were effected after analysis of the initial quantitative data. A sub-sample from the original sample was purposively selected based on results that were of interest and

that required follow up to fully understand teachers' concerns, perceptions and perspectives (question 1) about CAPS and how these impact their classroom practices (responding to questions 5 and 6). This phase involved five teachers, a sub-sample from the original group. Semi-structured interviews, lesson observations, field notes and a field journal were utilised as data collection tools.

3.6.2.1 Observations

For Berg (2007), observation is a way of measuring behaviour by watching people, events, situations or phenomena in natural settings. Creswell (2005: 211) defines observation as a process of gathering open-ended, first-hand information by observing people and places at research sites. While obtaining first-hand information, the researcher may engage as a participant observer or as a non-participant observer, (Atkinson & Hammersley, 1994).

There are, however, some drawbacks associated with using observations despite its strong merits and one of them is that they can be time consuming (Berg, 2007). Observations are not useful where the researcher is probing some behaviour that cannot be seen, such as somebody's feelings and oftentimes the information acquired through observations may not be meaningfully organised (Berg, 2007). Observations are also comparatively costlier to conduct on large samples. The objective for the observation was to characterise physical sciences teachers' practices during lessons including during practicals (experimental) and respond to question five:

How can the physical sciences teachers' practices on the new CAPS topics or subtopics be described?

The obtrusiveness factor as a challenge in observations is well documented (Gorman & Clayton, 2005). To reduce this factor, I visited each class before the actual observation. In most cases, the teacher would introduce me to the class and inform them that in a day or two I would come with a small video camera to observe and record classroom proceedings. On the actual day of observation, I did not appear as such a novel sight in the classroom and so attracted less attention.

Observations can be structured or unstructured (Mulhall, 2003; Punch, 2005). In most cases, post-positivists use structured observations consisting of taxonomies

developed from established theories. On the other hand, unstructured observations, those observations whereby the researcher has no preconceived notions beforehand, are closely associated with interpretive approaches (Mulhall, 2003). For this study, I used semi-structured observation. Although I took the position of a neutral, non-participant observer, I had to consider what is generally regarded as good teaching practices such as a decent introduction that captures learners' attention, the link between the content and everyday life examples, the teachers' questioning and waiting periods (Piburn *et al.*, 2000).

This pre-constructed template (Appendix D) for each observation was completed by watching the videos repeatedly and noting how teachers' decisions and practices adhered to what is generally considered good teaching practices according to recent and current research trends (Piburn *et al.*, 2000). During observations of practical experiments, I sought to characterise teachers' practices. I was interested in observing whether the teachers conducted the experiments as demonstrations, group experiments or as individual experiments. Furthermore, I wanted to observe how and to what degree, teachers exploited the learning opportunities and whether the practicals were open-ended or structured. I wanted to learn what kind of laboratory reporting teachers required from learners and how teachers handled safety related issues in the laboratory.

3.6.2.2 Document analysis

Written materials that researchers analyse to produce qualitative information are generally referred to as documents (Hancock, Windridge & Ockleford, 2009). Document analysis was conducted to respond in part to question five, which was phrased as:

How can physical sciences teachers' practices on the new CAPS topics or new subtopics be described?

With document analysis, I sought to identify the documents and the process through which the participants translated the original curriculum documents into classroom practices. Thus, I also sought to shed some light on how teachers were making sense of the main curriculum documents. To achieve this I used the document analysis guide (Appendix E). The documents I analysed included, lesson plans, work schedules

(Appendix G and H), worksheets (J and M), examinable content documents (Appendix I) and past examination question papers (Appendix K and L). Efforts to comprehend these documents extended to interviews and classroom observations. These documents met the four criteria of authenticity, representation, credibility and meaning for assessing the quality of documents, as suggested by Flick (2014).

3.6.2.3 Interviews

Interviews are arguably the main data collection tool for qualitative research as they provide in-depth information about the experiences and viewpoints of the participants concerning a phenomenon (Turner, 2010; Punch, 2005). Although there are different types of interview models in literature (Cohen, Manion & Morrison, 2007; Gall, Gall & Borg, 2007; Mulhall, 2003; Punch, 2005) most interviews fall within a continuum, with structured interviews on one end and unstructured on the other end (Turner, 2010). While a structured interview has a set of predefined questions and the questions would be asked in the same order for all respondents, for an unstructured interview, neither the question nor the answer categories are predetermined. A semi-structured interview is a flexible and more practical way of collecting data because question wording can be modified and explanations given (Turner, 2010). For this study, I used a semi-structured interview. I had a predetermined outline of the questions (Appendix F) but during the actual questioning, I had the flexibility to modify my questions based on the responses and the reactions from the participant.

Arranging interviews with research participants required flexibility, patience, persistence and some diplomacy. It was normal to have a participant cancelling an interview a few hours before the previously agreed time as much as it became the norm for a participant to ask for a change of venue. In a few cases, some teachers who had agreed to participate ended up opting out of participation. In the latter case, no explanations were sought from the teachers on why they had decided to quit as per agreed ethics rules and regulations. However, these eventualities had been anticipated. For example, I had requests for potential interviews with approximately 10 participants and they had initially agreed when I was expecting to only interview five to seven of them.

My interview preparations included analysing the data from the stages of concern survey questionnaire, the open-ended questionnaire, the demographic data and the observations. From the survey questionnaire, the individual profiles of all 81 participants were processed into individual profile graphs. Thus, when a participant had been selected for the interviews the outline of the semi-structured interview was slightly adjusted to find explanations to the participants' peak scores and second peak scores, to explore their responses to the short open-ended questionnaire and to probe some of their decisions that had been observed during the lesson observations. Face-to-face interviews allowed me to modify the line of questioning, follow up on participants' responses to clarify an issue and underline motives in a way that questionnaires would not be able to accomplish. Interviewing arrangements and ways of approaching issues were carefully planned and efforts were made to offset concerns regarding subjectivity and bias.

The interview outline composed of an introduction, outlining the purpose of the interview and thanking the participant for agreeing to the interview, assuring them of my adherence to confidentiality and ethical norms as I turn on my audio recorder (Phillips DVT 6000 voice tracer) to record the interview. Then I would proceed to ask general questions about the participant such as those related to their professional biography. The second round of questions was about their experiences with CAPS, questions about their individual profile from the stages of concern questionnaire and about some of their views as expressed in the open-ended questionnaire. The length of the interviews varied depending on the participant.

The conclusion part of the interview involved myself summarising the interview and the views of the participant to check if I had captured a true reflection of their perspectives and concerns. Finally, I would thank the participant, repeat my fidelity to confidentiality and ask for their permission to contact them if necessary.

3.7 Data documentation

To keep track of a growing volume of data in such a study it was necessary to devise a prudent way of data documentation or else the data collection and documentation may become time consuming, cumbersome and overwhelm me. This enabled me to keep track of growing volumes of notes, audio recordings and documents. The data

documentation provided me with a way of developing and outlining the analytical process and eased the subsequent process of conceptualisation and strategising on data analysis (Schutt, 2011).

Firstly, using the SoC questionnaire, an already validated data collection instrument, eased my data collection as it is structured in ways that organise the data as the completed questionnaires are conducted and collected. How the questionnaire data is captured from it, the conversions of the data to relative intensity profile graphs, conversions of raw data to percentiles are well documented by the developers (George *et al.*, 2013). For the interviews, the data was documented through writing notes during interviews and by reconstructing the original comments and text transcription from audiotapes (Schutt, 2011). A research journal for data condensation, data summarisation and data integration was also used (Spiggle, 1994). Audio recordings from interviews were listened to multiple times and notes were taken. Listening to these recordings multiple times also enabled me to relive my data experiences and enhanced my data analysis and data interpretation. This data analysis and data interpretation gave me a platform to retell teachers' stories (Creswell, 2013). After the data interpretation, these interpretations were returned to the participants to confirm their views and experiences.

3.8 Data analysis

The data analysis for this study was divided into two phases corresponding to the quantitative and qualitative stages, followed by integration of the two analyses in the discussions.

3.8.1 Soc and open-ended questionnaire quantitative analysis

Research question two, which sought to identify physical sciences teachers' concerns, was partly addressed during the quantitative phase by determining the stages of concern of the teachers with the highest intensities. The individual scores from the completed stages of concern questionnaire (Appendix C2) were entered onto the scoring device (Appendix C3) and the totals of the raw scores were scored on the scoring chart. Using the SoC percentile conversion chart (Appendix C4), the raw scores were converted into percentiles and these percentile scores were then used to construct individual profiles of the stages of concern relative intensity graphs. The raw

scores and the percentile scores were entered separately as SPSS data files. The percentile scores from the averaged raw scores were used to construct whole cohort and group relative intensity profile graphs.

Graphical profile analysis on the percentile scores of each respondent and sub-group were conducted for all seven stages and interpreting the meaning of the highs and lows and their interrelationships. Peak stage scores for the whole sample and for each sub-group were determined by examining the highest and second highest stage scores by using a data matrix to cross tabulate every participant's highest and second highest SoC (George *et al.*, 2006).

Demographic data from the open-ended questionnaire was analysed with the stages of concern questionnaire data. SPSS was used to tabulate the frequency data such as the number of responds with a particular level of education, gender and years of experience. The data on level of education and years of experience was used to test the hypotheses. To refute or confirm the hypotheses (in response to questions four and five), one-way between-groups multivariate analysis of variance (MANOVA) with post hoc tests were conducted to investigate the impact of level of education and years of experience on the stages of concern. For these analyses, raw scores rather than percentiles were used as percentile scores tend to skew the results to outliers. The p-values were compared to 0.05 to observe if the differences were significant. This was done after verifying that the data meets the required assumptions (Pallant, 2013).

3.8.2 Qualitative data analysis

This phase utilised narrative and content analysis to analyse the data collected during this phase. These two methods complemented each other. The narrative stage involved transcribing, retelling teacher concerns, member checking, redeveloping teacher stories, data tagging, coding and categorisation. Peers reviewed the codes and categories; thus, developing each individual story into categories. This was followed by conducting subject analysis of the relationship between codes and typologies with attributes. The data from the quantitative phase and the data from the qualitative phase were triangulated to gain a better insight into the sub-research questions.

3.8.3 Data analysis: Integration

Data integration is the mixing or combining of qualitative and quantitative data (Creswell & Plano Clark, 2011). This integration of data has the potential of making a mixed method study superior to any of the single approaches, as it increases robustness in responding to complex research questions. I am of the opinion this “mixing” produces a new hybrid that results in a better understanding of any complex phenomenon such as teachers’ concerns and perceptions during curriculum implementation. Integrating data in mixed methods minimises the weaknesses of the qualitative and the quantitative approaches but maximises the strengths of each of these two approaches (Creswell & Plano Clark, 2011).

There are three approaches to data integration that are currently being used to integrate these two different types of data: merging data, connecting data and embedding data (Creswell & Plano Clark, 2011). Merging data consists of combining qualitative data in the form of texts or images with numeric information from the quantitative phase. The integration was achieved by reporting data together in a discussion section of the study. In this study, the data were merged by reporting the quantitative statistical results first followed by qualitative quotes and themes that support or refute the quantitative results. This type of integration is referred to as connecting data (Creswell & Plano Clark, 2011). Embedding data refers to a dataset of secondary priority and is embedded within a larger, primary design (Creswell & Plano Clark, 2011). In this study, embedding data involved the collection of supplementary qualitative data regarding how participants are experiencing curriculum implementation after a quantitative survey. The supplementary data collected through interviews was to further describe and explain those aspects that the quantitative data could not fully explain.

3.9 Trustworthiness of the study

The methods used by quantitative and qualitative researchers to establish trustworthiness differ in many ways. For qualitative researchers, the methods used to establish trustworthiness include credibility, transferability, dependability and

confirmability. For quantitative researchers, the methods used to establish trustworthiness include internal validity, external validity, reliability and objectivity.

3.9.1.1 Validity and reliability of the SoC questionnaire

The stages of concern questionnaire (SoCQ) used in the initial quantitative phase was developed and validated in 1974 to quickly score the seven stages of concern of an innovation (George *et al.*, 2006). A group of researchers at the Research and Development Centre tested this instrument for Teacher Education at the University of Texas in Austin for estimates of reliability, internal consistency and validity with several samples of varying sizes and through different innovations (George *et al.*, 2006). Since then, this instrument has been used quite extensively for educational and non-educational innovations by a wide variety of researchers (George *et al.*, 2006). Some of the statistical procedures and analysis that have been tested on SoC data include inter-correlation matrices, judgements of concerns based on interview data and confirmation of expected group differences and changes over time as outlined in the Cronbach and Meehl validity test (George *et al.*, 2006). Further research to refine the instrument led to the generation of a 195-item pilot checklist. Table 3.6 below shows the alpha coefficients of internal consistency for each of the seven stages of concern scales.

Table 3.6: Internal reliability ratings of the SoCQ (George *et al.*, 2013:20)

Coefficient of internal reliability for the SoCQ							
Stage	0	1	2	3	4	5	6
Alpha	0.64	0.78	0.83	0.75	0.76	0.82	0.71

The coefficients reflect the degree of reliability among items on a scale in terms of overlapping variance computed using a stratified sample of 830 teachers in 1974 (George *et al.*, 2013). All stages except for stage 0 have the minimum requirement of 0.70.

Table 3.7: Test-retest correlations on the SoCQ (George *et al.*, 2013: 20)

Test-retest correlations on the SoCQ							
Stage	0	1	2	3	4	5	6
Alpha	0.65	0.86	0.82	0.81	0.76	0.84	0.71

Table 3.7 above shows the test-retest correlations of the stages of concern. Despite the evidence of high reliability of this questionnaire, the findings from the initial stage were still regarded as working hypotheses and were further explored throughout the subsequent qualitative phase which involved direct observations and semi-structured interviews.

Reliability for this study

When the data in this study were analysed for reliability using SPSS, the Cronbach's alpha coefficient was at 0.825, which, being above 0.7, showed high internal consistency. To investigate the influence of each item on the Cronbach alpha of the data, the Cronbach alpha was found if each item was deleted. The impact of each item on the reliability of the sample data was revealed by determining how the Cronbach alpha's coefficient would change if the item was deleted as in Table 3.8 below.

Table 3.8: Cronbach's alpha if item is deleted

Cronbach's alpha if the item is deleted SoCQ							
Stage	0	1	2	3	4	5	6
Alpha if the item is deleted	0.873	0.762	0.790	0.792	0.794	0.794	0.779

The internal consistency of the data would increase to 0.873 if the unconcerned scores (stage 0) were deleted. That means the unconcerned stage was reducing the internal consistency; hence, it was the least reliable of all the items, even though reliability was high at 0.825. The personal stage (Stage 1) scores contributed more to the internal consistency of the data. Therefore, if the item were to be deleted the alpha coefficient would decrease to 0.762.

3.9.2 Qualitative phase: Trustworthiness

Critics of qualitative research have questioned its trustworthiness in the past, perhaps because their concepts of validity and reliability cannot be addressed in the same way as in naturalistic work (Shenton, 2004). Some researchers have responded by addressing the issues of trustworthiness in qualitative research (Guba, 1981; Pitts, 1994; Silverman, 2001). Guba (1981) proposes four criteria that correspond to trustworthiness constructs used by positivists:

- a) Credibility (in preference to internal validity);
- b) Transferability (in favour of external validity/generalisability);
- c) Dependability (as opposed to reliability);
- d) Confirmability (instead of objectivity).

For the qualitative phase of this study to be trustworthy, I addressed these constructs as described below.

3.9.2.1 Credibility

Credibility is the qualitative equivalent to internal validity and is one of the important factors in establishing trustworthiness (Guba, 1981; Lincoln & Guba, 1985). Credibility refers to how consistent the results of qualitative research are with reality (Merriam, 1998). In this study, I used well-established research methods such as observation and interviews. Other researchers have used the observation protocol extensively. The line of questioning used in the interviews although flexible, is a well-established interviewing procedure. The transcription, coding and categorising of data that I employed in this study are standard procedures. Triangulation was employed as one of the different data collection methods in this study. Observations, interviews and document analysis were used and this compensated for their separate limitations and reinforces their strengths (Lincoln & Guba, 1985; Brewer & Hunter, 1989). Documents such as the examinable content document, the work schedules that the interview participants referred to as guiding their lesson plans were checked and in the process claims made by the participants during interviews were compared. Cases that showed discrepancies were probed further.

Thick descriptions were presented and in some cases, the questions I posed during the interviews were included to give the context in which these thick descriptions were generated.

At different stages of this study, peers scrutinised and gave their feedback, especially on the claims, discussions and the basis on which data interpretation and conclusions were based. These peer reviews were encouraged and supervised by the supervisor of this study. Supporting these peer-to-peer interactions were regular individual debriefings from the supervisor that revolved around issues of trustworthiness and research ethics. Previous research findings related to teachers' perspectives and practices during curriculum reforms in South Africa and from international studies were examined in chapter two. One reason this was conducted was to assess the extent to which the study's results were congruent with those of past studies considering any contextual differences (Shenton, 2004). My experiences as a researcher and as a former teacher in the Motheo district in addition to my familiarity with the circumstances and context in which the study was carried out meant that the participants could trust me especially after explaining the ethics of the study to them, including confidentiality. During interviews, the participants were in a better position to be open and truthful and they know I was familiar with the broad generalities of their work-related circumstances.

3.9.2.2 Dependability

Where the positivists refer to reliability, qualitative researchers use dependability as a measure of trustworthiness (Lincoln & Guba, 1985, Shenton, 2004). Employment of "overlapping methods" and an in-depth methodological description to allow the study to be repeated are two ways in which I improved the dependability of this study (Shenton, 2004).

The methodology, instruments, procedures and data analysis for this study have been described and reported in enough detail to allow other researchers to reproduce it within reasonable limitations. However, the changing nature of teachers' concerns and perspectives may mean that another researcher might not obtain the same results or reach the same conclusions. As suggested by Shenton (2004), in the final report I

have included the following to assist any prospective researcher who intends to reproduce the study:

- ✓ the research design and its implementation, describing what was planned and executed on a strategic level;
- ✓ the operational detail of data gathering, addressing the minutiae of what was done in the field;
- ✓ Reflective appraisal of the project, evaluating the effectiveness of the process of inquiry undertaken.

3.9.2.3 Transferability

The qualitative equivalent to transferability is what the quantitative researchers refer to as external validity and is concerned with the degree to which the findings of a research study can be applied to other contexts (Merriam, 1998). The thick descriptions provided in the data presentations and subsequent analysis provides prospective researchers with contexts that shaped the experiences of the participants in this study. With these contexts in mind, prospective researchers can assess how these experiences relate to those situations where they seek to comprehend the phenomena (Merriam, 1998). In this study, I requested plenty of personal information from the participants (with their consent) and followed up on their responses during the interviews. Despite the importance that other researchers assign to transferability, Shenton (2004) cautions on that, pointing out that it is more important to assume that each context is different. Hence, Shenton (2004) emphasises that the only way to assess the extent to which findings are applicable to other contexts is to conduct similar projects employing the same methods in those settings. In fact, conducting similar studies in other provinces would contribute to giving a more complete and more inclusive picture of the CAPS curriculum implementation in physical sciences in South Africa (Shenton, 2004).

3.9.2.4 Confirmability

Confirmability is the qualitative equivalent to objectivity (Lincoln & Guba, 1985; Shenton, 2004) and it refers to the degree to which other researchers can corroborate and confirm the results of a research study (Lincoln & Guba, 1985; Shenton, 2004). For a study to satisfy the confirmability criteria, the researcher's bias has to be reduced and therefore, the interpretations and conclusions of the study emerge from

the data collected during the study (Shenton, 2004). Miles and Huberman (1994) consider that a key criterion for confirmability is the extent to which researchers admit their own biases. Triangulation reduces bias. Throughout this study, all decisions I made were justified and my beliefs that led to the decisions including decisions regarding selection of methods were explained. The use of a reflective commentary throughout the study allowed me to promote confirmability. Through such reflection, whenever I have made my own suppositions, partially or not supported by the data, I have made that clear and in some cases suggesting the need for further research. Triangulating data from different sources also improved the conformability of this study.

3.10 Ethical issues

For this study, standard procedures to obtain ethical clearance from the relevant authorities at the university were followed and ethical permission was granted (Appendix A1). Permission to conduct the study in schools within the Motheo district of the Free State was sought and granted from the Free State Department of Basic Education (Appendix A2). The Free State Department of Basic Education also wrote a letter to the Motheo District informing them that I was going to carry out the study in their district. I wrote letters to school principals, seeking permission to carry out the study in their schools (Appendix B1). Physical sciences teachers' consent in the research was sought (Appendix B2) after clearly explaining to all potential participants what the study was about. The participants signed the consent after I had explained to them that they had the right to pull out of the study anytime they feel uncomfortable and they did not necessarily need to offer an explanation. They were assured of confidentiality and that they would remain anonymous as pseudonyms would be used for them and codes for their schools where necessary. To enhance the validity of the study, I ensured honesty and integrity throughout the research.

The final reports on this study will be made available to the participants and their schools and a copy will be available at the University of the Free State. The study results will only be used for the purpose that they are being conducted for: academic purposes. Data were secured through password protected safe storage to ensure that no unauthorised persons could gain access to any information in ways that may compromise the integrity of the participants.

3.11 Conclusions

In chapter 3, I presented a description of the empirical methods that were used to conduct this research. I further elucidated the research study strategy, which is the mixed sequential explanatory strategy and the selection of this approach was justified. The appropriateness of the instruments to respond to the sub-research questions was also discussed. A detailed description on the process of data collection, its analysis as well as the interpretation thereof has been presented. A brief discussion on the pilot study that was carried out to ensure that the instruments measure what I intend them to measure has also been included. The chapter was presented in such a way that can enable an experienced researcher to replicate a similar study within certain reasonable limits.

In the next chapter (Chapter 4), I present descriptions of the research findings on teachers' perspectives, concerns and practices regarding current reform efforts in the Motheo district of the Free State, South Africa. These include the data analysis and their interpretation from the two phases of the study. I also describe my experiences in the interactions with teachers in the Motheo district. In my descriptions, I ensure that these teachers' experiences are described in the best way possible to give a vivid picture on what is going in the classrooms pertaining to curriculum implementation as well as what goes on in the teachers' minds. Thus, through the data analysis and the interpretation thereof, I synthesise how the study responds to the research question.

Chapter four: Findings of the study: Analysis and discussions

4.1 Introduction

In this chapter, I discuss the research findings on physical sciences teachers' perspectives and concerns regarding current reform efforts in the Motheo district of the Free State. I also describe correlations between the stages of concern raw scores and variables such as the experience and educational qualifications of the participants to respond to the sub-research questions. I describe the results from document analysis, interviews and observations. In my descriptions, I attempt to paint a vivid picture of classroom proceedings pertaining to CAPS implementation and give possible explanations for teachers' decisions in the classroom.

4.2 Demographic data of the participants

Table 4.1 below summarises the demographic data of the participants.

Table 4.1: Summary of demographic data of participants

<i>Variable</i>	<i>Frequency</i>	<i>Percentage</i>
<i>Years of experience</i>		
Under 5 years	12	14.8
5-10 years	20	24.7
11-15 years	14	17.3
16-20 years	18	22.2
More than 20 years	17	21.0
Total	81	100.0
<i>Years of experience with physical sciences CAPS</i>		
0 years	4	4.9
1 year	14	17.3
2 years	14	17.3
3 years	23	28.4
4 years	26	32.1
Total	81	100.0
<i>Educational qualifications</i>		45.7
Certificate or Diploma	37	46.9
First degree	38	7.4
Postgraduate	6	100.0
Total	81	
<i>Topics taught</i>		

Both chemistry & physics		75	92.6	
physics only		4	4.9	
chemistry only		2	2.5	
Total		81		100.0
<i>Subject majored in</i>				
Physical sciences		38		46.9
Physics or physics education only	23		28.4	22.2
Chemistry or chemistry education		18		2.5
Other		2		100.0
Total		81		59.3
<i>Gender</i>				
Male		48		40.7
Female		33		100.0
Total		81		

The demographic data shows that 14.8% had less than five (5) years of experience as physical sciences teachers while 24.7% had between five and ten years of experience in teaching. Seventeen point three per cent had been teaching for between eleven and fifteen years while 22.2% had between sixteen and twenty years of teaching experience. Those with more than twenty years of teaching constituted 21.0% of the participants.

Generally, the Motheo district physical sciences teachers who participated in this study were quite experienced with 85.2% having taught for at least five years. However, with 43.2% of participants having taught for more than 15 years, the sample in this study was less experienced than the sample in Ramatlapana and Makonye's (2013) study on teacher autonomy under CAPS. In their study, 61% of the participants had more than 15 years of teaching experience.

The participants who had been teaching CAPS since its inception in 2012 constituted 32.1%. An equal percentage (17.3%) of participants had one year and two years of teaching experience under CAPS and for 4.9% of the participants, 2016 was their first year of teaching under CAPS. Thus, most of the participants were already teaching physical sciences when the CAPS workshops were rolled out.

In terms of educational qualifications, 45.7% had a certificate or a diploma, while 46.9% had attained a first degree and those with a postgraduate qualification (either an honours or a Master's degree) constituted a mere 7.4%. Generally, the participants in this study constitute a teaching workforce with a higher level of education than that of the study to evaluate the readiness of physical sciences teachers to implement CAPS (Basson & Kriek 2012) from Gauteng, North West and the Western Cape in South Africa. In this study, 80% of teachers did not possess any teaching qualifications in physics, chemistry or physical sciences. However, while 46.9% from this study sample were degree holders, 65% of the participants in a study by Ramatlapana and Makonye (2013) were degree holders.

While almost half of the participants (46.9%) had a major or minor in physical sciences 28.4% had only majored in physics or physics education and 22.2% had majored in chemistry or chemistry education. In a few schools, teachers specialised in chemistry or physics, with most participants (92.6%) teaching chemistry and physics, while 4.9% taught physics topics only and 2.5% taught chemistry topics only. This breakdown of academic qualifications in terms of physics and chemistry levels is often missing in studies of physical sciences teaching.

Most participants in this study (59.3%) were male. This almost coincides in percentage proportions with the composition of participants in a study by Ramatlapana and Makonye (2013), which had 31 males (59.6%) and 21 females (40.4%).

4.3 Presentation and discussion of stages of concern results

According to the developers of the instrument, caution must be exercised in accepting the stages of concern questionnaire (SoCQ) data as the final truth (George, Hall & Stiegelbauer, 2013; Hall & George, 2013; Hall, George & Rutherford, 1998; Hall & Hord, 2011). Hence, the interpretations in this initial phase were treated as tentative truths that warranted confirmation through subsequent observations and interviews. When analysing profiles, emphasis should be placed on relative scores rather than absolute values (George *et al.*, 2013, Hall *et al.*, 1998).

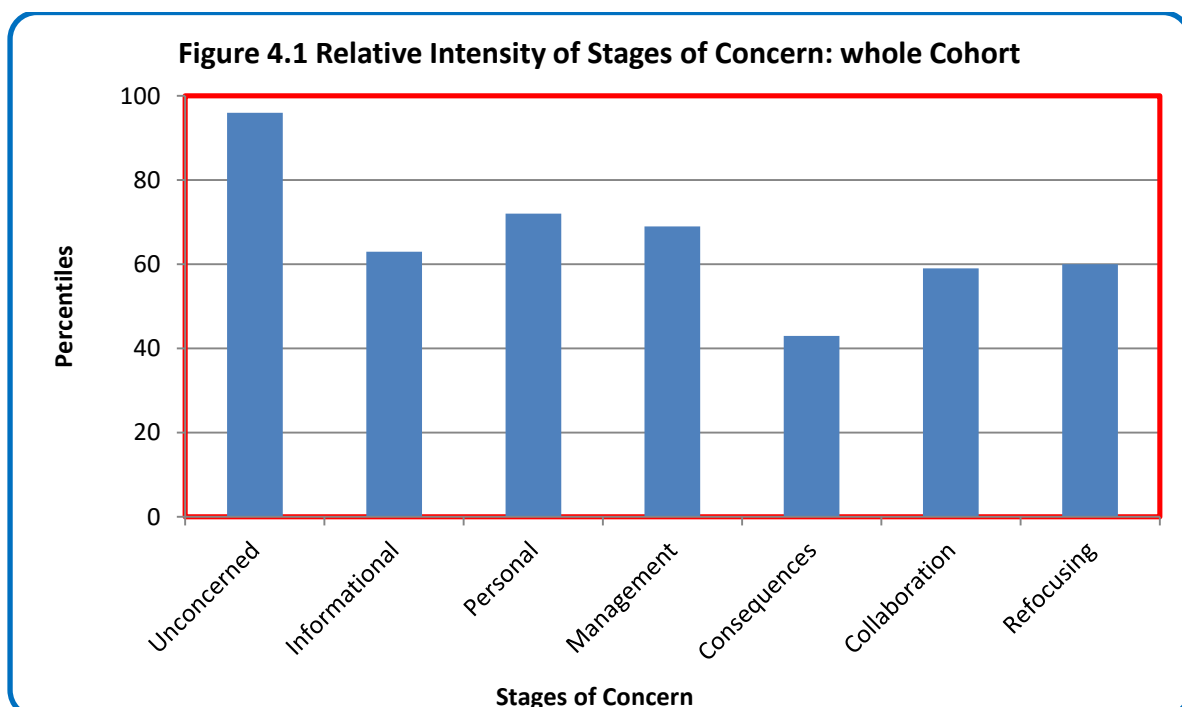
4.3.1 Whole group profile: Raw mean scores and relative intensity

Relative intensity profiles are useful in indicating the relative intensities of teachers' stages of concern (George *et al.*, 2013). The recommended procedures to construct

relative intensity profiles (George *et al.*, 2013; Hall, *et al.*, 1998) were followed. This involved entering the individual scores from the completed stages of concern questionnaire (Appendix C2) onto the scoring device (Appendix C3) and recording the totals of the raw scores on the scoring chart. Using the percentile conversion chart (Appendix C4) the raw scores were converted into percentiles and these percentile scores were then used to construct individual profiles of the stages of concern relative intensity graphs. The raw scores and the percentile scores were entered as separate data files in the statistical package for social sciences (SPSS). Raw scores were used for data analysis such as the One-Way Multivariate Analysis of Variance (One-Way MANOVA) while the percentile scores from the averaged raw scores were used to construct whole cohort and group relative intensity profile graphs.

4.3.2 Relative intensity of concerns of the whole cohort

The developers recommend using percentile scores to construct the whole cohort, group and individual intensity graphs (Hall & Hord, 2011; George *et al.*, 2013; Hall & George, 2013; Hall, *et al.*, 1998). The recommended procedure is to get the mean raw scores of the individuals from the whole cohort and to average these by dividing them by the number of stages of concern (7). These mean raw scores are converted to percentiles using the conversion chart (Appendix C4) (George, *et al.*, 2013).



The relative intensities of concern for this study are shown in figure 4.1 above.

The highest percentile is at unconcerned, with second and third peaks at personal and management respectively. The highest score on the unconcerned stage indicates that the participants were probably more concerned about other tasks and activities not necessarily about CAPS. In such a case, the second and third peaks become more significant at hinting what those concerns could be (George *et al.*, 2013; Hall & George, 2013; Hall & Hord, 2011; Hall, *et al.*, 1998). The second peak at the personal stage indicates that the participants were more affected by self-concerns (Fuller, 1969); for example, respondents may be more concerned about how CAPS affects them personally and about how CAPS implementation benefits them on a personal level (George *et al.*, 2013; Hall *et al.*, 1998). They could be more concerned about how CAPS makes their work easier. It also indicates the possibility that teachers are uncertain about the demands of CAPS, how these demands differ from the previous NCS demands and making them unsure about their role in the current implementation process (George *et al.*, 2013; Hall *et al.*, 1998).

The third highest peak was found at the management stage, suggesting that most of the participants were concerned about the processes and requirements for using CAPS, efficiency, coordination, scheduling and time constraints. The lowest score, at the consequence stage, suggests that the Motheo district physical sciences teachers were less concerned about how CAPS affects their learners.

According to the developers of the questionnaire, the stages of concern relative intensity graph indicates progression when the highest and the second highest stages are adjacent to each other (George *et al.*, 2013; Hall *et al.*, 1998). Progression in this case refers to the relative intensities of teachers' moving from lower stages of concern such as unconcerned, informational and personal to higher stages of concern such as collaboration and refocusing. It is an indicator of good implementation when the relative intensities are high for the higher stages of concern. When an innovation is introduced, teachers' concerns gradually progress from lower to higher stages (George *et al.*, 2013; Hall *et al.*, 1998). When this progression happens, the highest and second highest peaks will always be found adjacent to each other. However, in this sample, highest and second highest peaks are not adjacent to each other, indicating a probability that the intensity of teachers' stages of concern were not yet

progressing from lower to higher stages of concern (George *et al.*, 2013). Physical sciences teachers in Motheo district appeared to be preoccupied with personal, management and informational concerns, which might be preventing progress towards the higher concerns (George *et al.*, 2013; Hall *et al.*, 1998). Until these are resolved, teachers' most intense concerns will remain centred in the lower stages of concern instead of progressing to the higher stages of concern such as such at collaboration and refocusing (Becker, 2013; George *et al.*, 2013; Hall *et al.*, 1998).

4.3.3 Relationship between stages of concern and demographic data using One-Way Multivariate Analysis of Variance (One-Way MANOVA)

Demographic data such as number of years of experience or level of academic qualification may assist a researcher to explain stages of concern results (George *et al.*, 2013; Hall *et al.*, 1998). In this study, I formulated hypotheses from the third and fourth sub-research questions (restated below) and tested these using SPSS. One-way between-groups multivariate analysis of variance (One-Way MANOVA) tests were conducted to investigate the relationship between stages of concern and demographic data such as level of education, years of teaching experience and years of teaching under CAPS. Raw score data were used rather than percentile scores as conversion to percentile scores tends to make the distribution of scores rectangular resulting in possible violations of assumptions on which the tests are based (George *et al.*, 2013; Hall *et al.*, 1998). In all three cases, preliminary checks for linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, multicollinearity, and normality were carried out on the data (Pallant, 2013). No serious violations were identified. Below I describe each case.

4.3.3.1 Level of education versus stages of concern

In analysing the relationship between demographic data and stages of concern, I sought to respond to sub-questions three and four.

.Question three states:

What are the relationships, if any, between physical sciences teachers' stages of concern and level of education?

From question three, the following **null hypothesis** was formulated:

There is no correlation between raw scores of each of the stage of concern based on levels of educational qualifications.

To test the hypothesis, one-way between-groups MANOVA tests were conducted to investigate the impact of level of education on the stages of concern, as measured by the SoCQ. The independent variable was the level of education. Participants were divided into two groups according to their educational qualifications: 1) Certificate/Diploma and 2) University Degree. The numbers at Certificate and Master's level were small, hence the groupings above, so that data could have large enough frequencies to meet one of the criteria required for such an analysis.

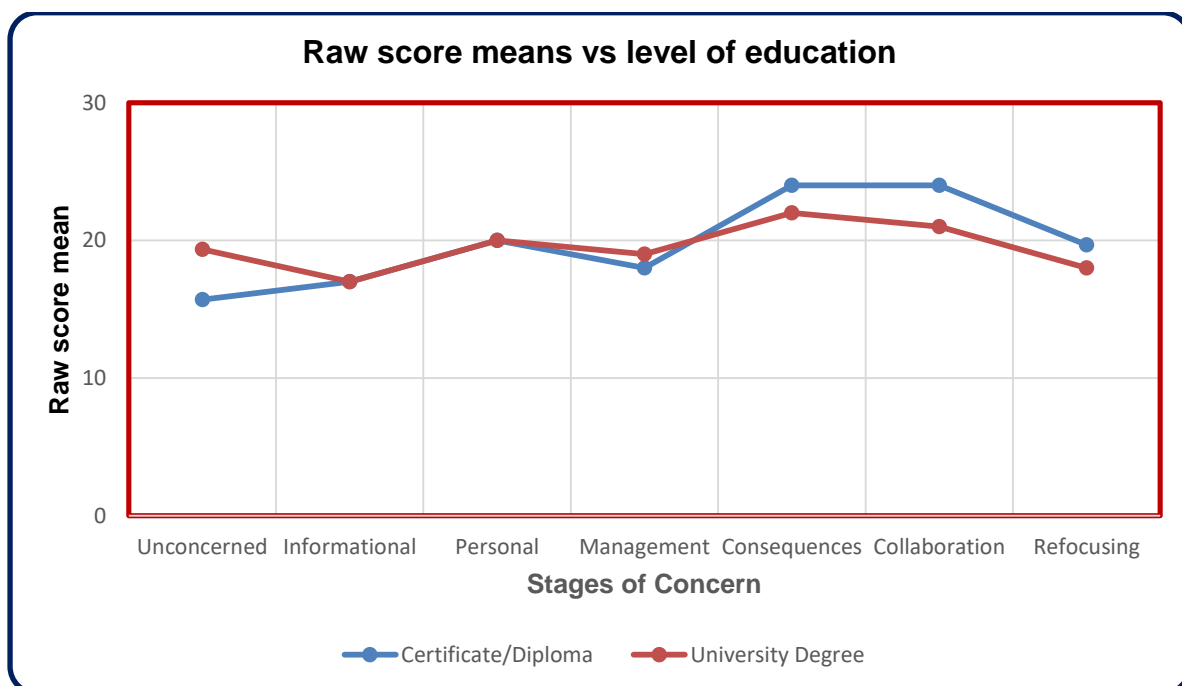


Figure 4.2: Raw score means for stages of concern vs level educational qualifications

Figure 4.2 above shows the graph of mean raw scores plotted against level of educational qualifications. The mean raw score did not appear to differ significantly according to educational qualifications.

Statistically, there was no significant difference at the $p < 0.05$ level between those with university degrees and those without university degrees on the stages of concern raw scores, $F(7, 73) = 2.12$, $p = 0.051$; Wilks Lambda = 0.83. The one-way MANOVA result suggested that at the $p < 0.05$ significance level, there is no evidence to reject the null

hypothesis, so I concluded that the raw score means for each stage of concern are independent of educational level.

4.3.3.2 Years of teaching experience versus stages of concern

Research **question four** was phrased as: *What are the relationships, if any, between physical sciences teachers' stages of concern and number of years of teaching?*

The **null hypothesis** below was formulated from the above question: *There is no correlation between raw scores of each of the stages of concern and physical sciences teachers' number of years of teaching experience.*

One-way MANOVA tests were conducted to investigate the impact of number of years of teaching experience on the stages of concern. The independent variable was the number of years of teaching experience and the dependent variable was the raw score means for the stages of concern. Participants were divided into five groups according to the number of years they had been teaching up to February 2016; 1) more than 20 years 2) 16-20 years 3) 11-15 years 4) 5-10 years 5) under 5 years.

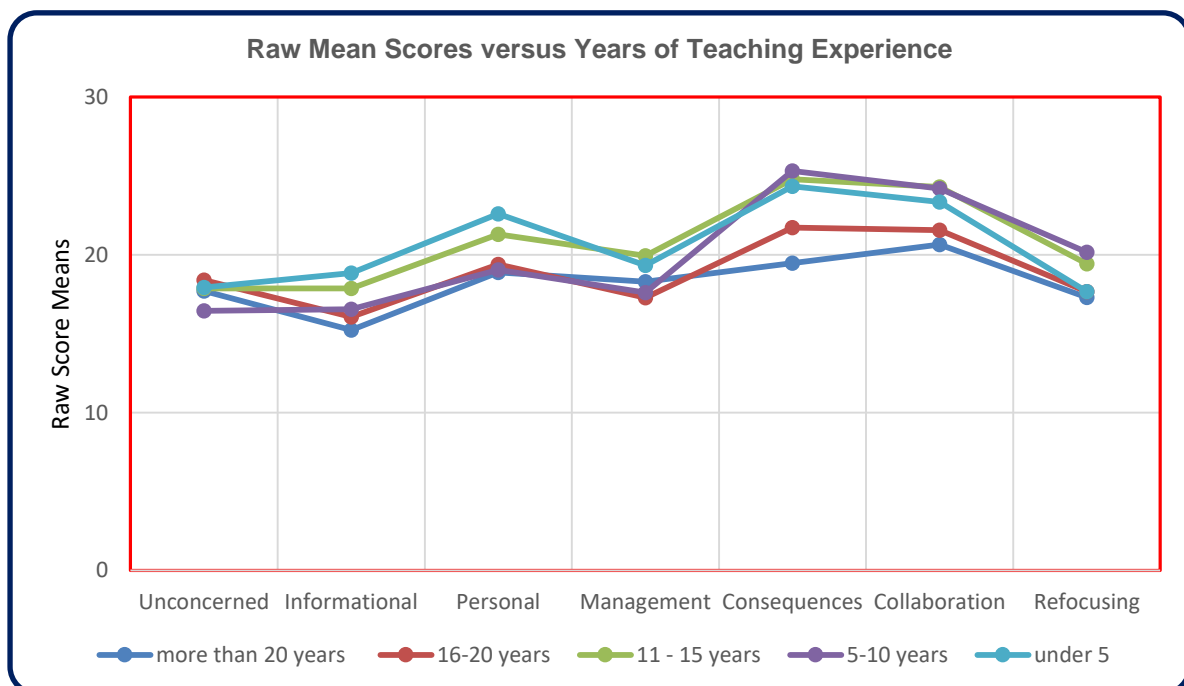


Figure 4.3: Raw score means of stages of concern vs years of teaching experience.

Figure 4.3 above shows the graph of raw score means plotted against years of teaching experience. The mean raw scores did not appear to differ significantly according to the number of years of teaching experience.

Statistically, it was confirmed that there was no difference at the $p < 0.05$ significance level among the five groups on the stages of concern raw scores, $F(28, 53) = 0.74$, $p = 0.83$; Wilks Lambda = 0.76. The MANOVA test results provide no evidence to reject the null hypothesis, so I concluded that the raw score means were independent of the number of years of teaching experience.

Stages of concern statistics

Some studies in the literature review deviated in terms of procedures from the recommendations by the SoCQ developers. These warrant highlighting. The problems associated with the use of mean scores (Çentinkaya, 2012) in constructing the cohort profile, instead of using converted percentile scores, has already been mentioned. Significantly, when the SoCQ recommended procedure was used for this study, the highest stage of concerns was found to be “unconcerned”; however, had the procedure suggested by Çentinkaya (2012) been followed, the stage of concern with highest intensity would have been the collaboration stage.

4.3.4 Conclusions of the stages of concern results and discussion

The above results from the stages of concern analysis were limited in different ways. The results showed that most Motheo district physical sciences teachers were unconcerned about the CAPS curriculum, but were probably concerned about other tasks and activities that were not necessarily or directly associated with CAPS (George, *et al.*, 2013; Hall, *et al.*, 1998). However, the results did not reveal what those tasks and activities were or explain why those tasks and activities were of more concern to the physical sciences teachers instead of the CAPS curriculum. Secondly, though the results revealed the personal stage of concern as the second highest in relative intensity, these results were not specific about what these personal concerns were. While the management stage of concern was third highest in intensity, the results suggest that the participants had some concerns about coordination, managing time and managing different tasks (George *et al.*, 2013; Hall *et al.*, 1998) but these findings do not specify what tasks these were or what was causing these time

management concerns. The one-way MANOVA tests confirmed the null hypothesis, suggesting no correlation between raw scores of each of the stages of concern and physical sciences teachers' number of years of teaching experience. The raw scores did not differ significantly according to level of educational qualifications of the participants.

The above results could only be fully understood and explained with further exploration using a qualitative approach. Below, I describe the qualitative phase in which I conducted lesson observations, interviews and document analysis. The objectives of the qualitative phase therefore were, firstly, to respond to sub-research questions one, five and six, and secondly, to explore further the data from the stages of concern questionnaire. In the process, data from the two phases complemented each other to provide a more complete understanding of Motheo district physical sciences teachers' perspectives and practices during CAPS implementation.

4.4 Qualitative Phase: Analysis and Discussion of results

4.4.1 Introduction

The qualitative phase involved classroom observations, document analysis and interviews of case selected participants from the original sample. Data from the stages of concern survey was used to construct graphic individual profiles of the 81 participants, which were interpreted. Five participants were selected, with consent sought and granted, for further observations and interviews. I sought representation from different backgrounds such as gender, educational qualifications and type of school. During these observations, I sought to determine, first hand, teachers' classroom practice. Observations were conducted then followed up with interviews, during which it was possible to explore some of the decisions observed in the classroom practice. Two observations were carried out for each of the five participants: one class lesson observation and one experimental class observation. In all cases, I had visited the class before the first observation to be familiar with the learners and reduce the issue of obtrusiveness on the actual days of observing.

4.4.2 Emerging themes from qualitative phase

The coding and categorisation of the interview transcripts and observation sheets resulted in different themes being identified (Table 4.2 below). The themes were

further divided into subthemes and categories. The main themes emerging from question 1 were related to teacher expressions on CAPS, from which emerged subthemes that pertain to teachers' attitudes and perspectives on CAPS. The fifth question generated themes content, practical experiments and knowledge, while the sixth question generated subthemes related to teaching approaches, content coverage and practical experiments.

Table 4.2: Summary of emerging themes

Sub-research questions themes, subthemes, and categories			
Sub-research questions	Themes	Subthemes	Categories
What perspectives do physical sciences teachers have about the changes in the CAPS?	Theme 1: Teacher expressions on CAPS	Subtheme 1.1 Attitudes	Category 1 Negative
			Category 2 Neutral
			Category 4 Positive
		Subtheme 1.2 Perspectives	Category 1 Changes to tackle NCS challenges
			Category 2 Progressed learners
			Category 3 New subtopics
How can physical sciences teachers' practices on some of the new CAPS topics or new sub-topics be described?	Theme 2: Treatment of new topics	Subtheme 2.1 Content lessons	Category 1 Emission and Absorption Spectra
			Category 2 Polymers
		Subtheme 2.2 Practical lessons	Category 1 Titration
			Category 2 Esterification
		Subtheme 2.3 Knowledge	General knowledge about CAPS changes
			Category 1 Subject content knowledge (SCK) on new topics
Category 2 Pedagogical content knowledge (PCK) on new topics			
How do physical sciences teachers' concerns and perspectives on CAPS influence their classroom practices?	Theme 3: General classroom challenges from NCS	Subtheme 3.1 Teaching approaches	Category 1 Teacher-centred
			Category 2 Learner-centred
		Subtheme 3.2 Content coverage	Category 1 Time constraints
			Category 2 Insufficient knowledge domains
		Subtheme 3.3 Practicals	Category 1 Time constraints
			Category 2 Insufficient practical skills

4.4.3 The five teachers selected for observations and interviews

Below I present the observation and interview data from each of the five participants at this qualitative phase. I firstly present their relative intensity profile from the stages of concern data. Assumptions made from the profile data are discussed. Then the observation data is presented and discussed. Comments on methodology are meant to be suggestive from myself as an observer and are not exhaustive on ways content could be presented.

4.4.3.1 Andres, a multiple peak profile

Andres was teaching physical sciences for the past 11 years at the same, previously-coloured, school at which he matriculated.

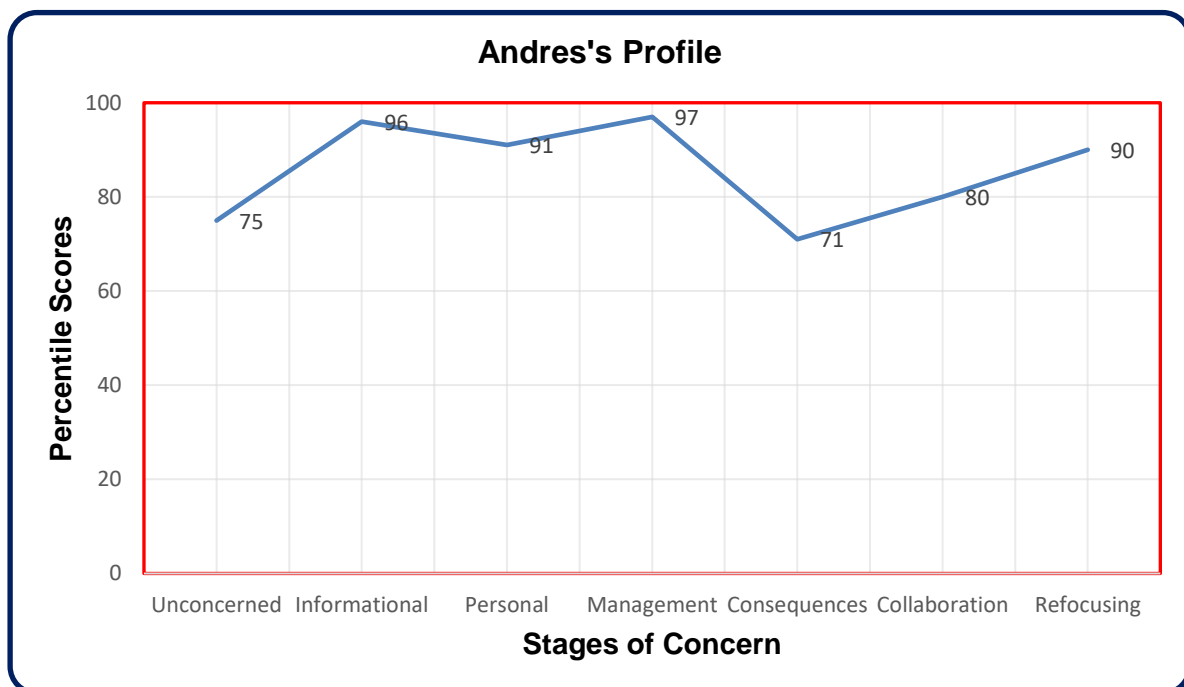


Figure 4.4: Andres' individual relative intensity profile

Andres majored in pure physics, graduating with a BSc, and was the only physical sciences teacher at the school; hence, he taught both chemistry and physics topics. Andres also taught part time at the local university on weekdays in the evenings and on some Saturdays. Andres' profile (Figure 4.4, above) is a multiple peak profile with the highest peak at Management (97.0), suggesting intense concerns with coordination, managing time, managing different tasks (George *et al.*, 2013; Hall *et al.*,

1998). He has other prominent peaks at the personal (91.0), informational (96.0), and refocusing (90.0) stages. His lowest score was at the consequences stage showing he was less concerned about how CAPS impacts his learners. With unconcerned as one of his lowest stages at 75.0, Andres' profile deviates from the whole cohort profile, which had 'unconcerned' as the most intense Soc. I sought to find out the conditions that make his profile deviate from the rest of the group in that respect.

Andres' class

I observed Andres' class on acids and bases for grade 12. His introduction involved a brief demonstration on testing acidity and basicity using universal indicator and litmus paper. He had the 16 learners around his table as he tested different substances for acidity and basicity. Among the common laboratory acids and bases used as specimens, there were also some home substances such as a liquid detergent, a lemon, a tomato, a fizzy drink, tap water and milk. This was, in my opinion, an excellent way to show the applicability of chemistry in everyday life at the macroscopic level or representation. After this brief exercise, he turned the learners' attention to what they had covered in Grade 11 on acids and bases by tabulating the information on the blackboard (Table 4.3, below).

Table 4.3: Revision: Comparing and contrasting of Acids and bases

Acids	Bases
Taste sour	Taste bitter
Changes blue litmus paper to red	Changes red litmus paper to blue
Reacts with carbonates to release carbon dioxide	Reacts with organic matter
Reacts with most metals to release hydrogen gas	Reacts with aluminium to form complex ions.
Nitric acid, sulphuric acid, hydrochloric acid	Sodium hydroxide, Potassium hydroxide
pH range below 7	pH range above 7, up to 14

However, his initial attempts to complete the table with the assistance of the learners were futile, as most learners seemed to have forgotten about the content.

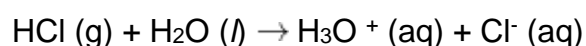
After completing the table Andres proceeded to define acids and bases using the Bronsted-Lowry and the Arrhenius models for acids and bases. Andres wrote the two definitions of acids based on the two models as the learners wrote into their notebooks. This part of the content is also supposed to have been treated for the first time in Grade 11, third term, week 13 (See Appendix G, work schedules). No due considerations or discussions of the context that led to the development of the two models was encouraged. Andres could have made references to who Bronsted and Lowry were or who Arrhenius was and how these models had developed or why they had been named after these three scientists. If these had been discussed at grade 11, it would have been prudent to reinforce the role of scientific models to learners. Teachers need to demonstrate to learners that scientific models are human constructions and are only limited representations of reality. However, for teachers to achieve the above, they need to developed the appropriate pedagogical content knowledge (Harrison and Treagust, 2000).

The other aspect of the lesson that caught my attention was use of multiple representations to develop the concepts in the class. For example, in developing the concept of weak and strong acids, he used two representations: firstly, the macroscopic representation in the initial demonstration, and secondly the symbolic representation through the equation below. The learners were referred to the examinable content document for the definition of a strong acid and the following was written on the blackboard. (The examinable content document is a document that summarises the content from which examination questions are set; see Appendix I).

Strong acid:

A strong acid dissociates completely in water:

For example, HCl is a strong acid

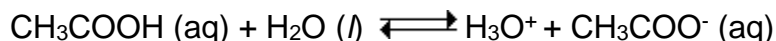


strong acids dissociate completely in water

Weak acid:

A weak acid dissociates incompletely or partially in water

CH₃COOH is a weak acid



In both cases, the two equations are symbolic representations of the concept of acid dissociation in water.

While this was clearly discussed with the learners, sub-microscopic representations of solutions dissociating could have been helpful to reinforce learner understanding of the concept. Chemical knowledge is learned at three levels or representation: macroscopic, symbolic and sub-microscopic, and the link between these levels should be explicitly taught (Ebenezer, 2001; Ravialo, 2001; Treagust *et al.*, 2003).

Andres' lesson could have included all representations: with the inclusion of Figure 4.6 below, showing sub-microscopic representation. Learners understand chemistry concepts better when the teaching and learning process progresses from the concrete to the abstract (Kennedy, 1996). In congruency with that, in grades 10 and 11, the macroscopic and symbolic representations should dominate and then in grade 12 more emphasis should be on the sub-microscopic representations. At Grade 12 the process should culminate in, firstly, emphasising the abstract through sub-microscopic representations and secondly the integration of the three representations.

Thus, Andres' presentation could have had better chances of achieving learner understanding if he had roughly presented in the following order:

- 1. Macroscopic representations:** Showing the actual acids and testing using universal indicator (this was done)
- 2. Symbolic representation:** $\text{HCl (g)} + \text{H}_2\text{O (l)} \rightarrow \text{H}_3\text{O}^+ \text{ (aq)} + \text{Cl}^- \text{ (aq)}$

(This representation was explored)

3. Sub-microscopic representation (this representation was not explored)

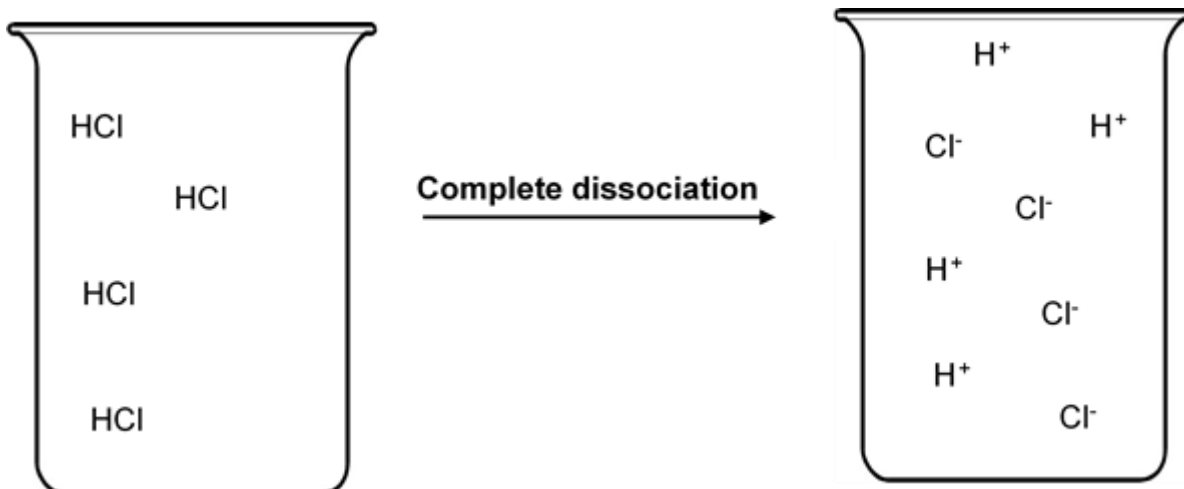


Fig 4.5: Sub-microscopic representation of strong acid dissociation (by R. Gudyanga)

All HCl molecules dissociate to form H⁺ and Cl⁻.

This is an example of complete dissociation shown through microscopic representation (see fig. 4.5 above).

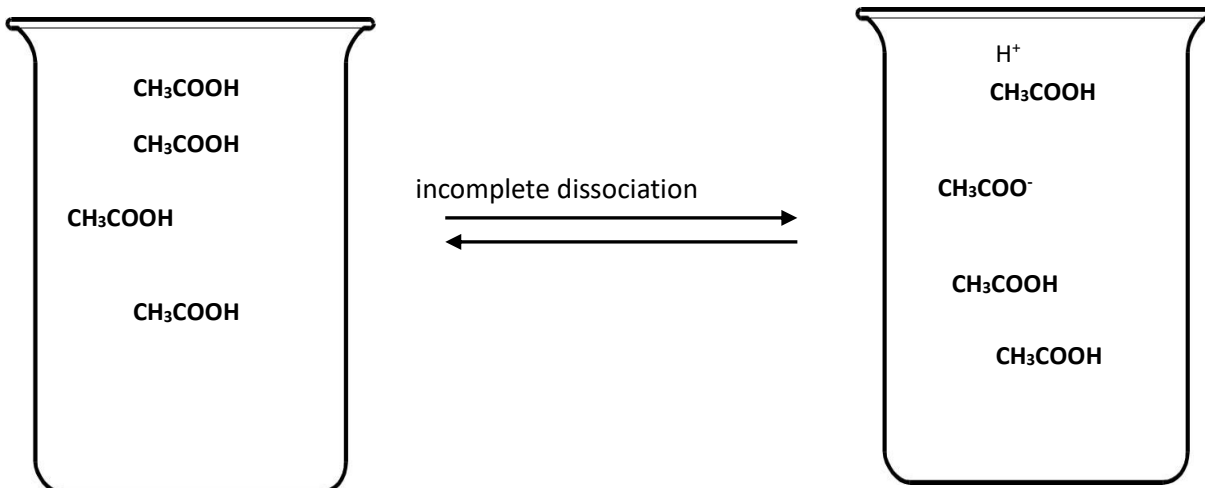


Fig 4.6: sub-microscopic representation of weak acid dissociation (by R. Gudyanga)

Weak acids like acetic acid (vinegar) do not dissociate completely.

Some CH₃COOH molecules do not dissociate. So, CH₃COOH undergoes partial dissociation (see fig 4.6, above).

The conclusion could involve integrating this sub-atomic representation with the other two representations.

Andres' Laboratory practices: A titration experiment:

My observation for Andres' experiment was announced. When I entered his laboratory, he explained that he had given the worksheet to the learners (Appendix J) the previous day. He also explained that he had divided his grade 12 class of 17 learners into two groups: the first group of eight would do the experiment the following period, while the second group with nine learners would do the experiment the following day in the afternoon, after official school hours.

A brief orientation was given to the learners. The experiment was individual and each learner was responsible for collecting the apparatus from the inner storeroom (which was just adjacent) and for setting up their workstation. Chemicals were on the teachers table and were labelled. However, before the setting up of the workstations the teacher led the class in revising Part A (see Appendix J) which involved the calculations. Here, Andres went to the blackboard himself and showed all the calculations while some corrected their mistakes. After that it was time to collect apparatus and set up the workstations.

Collection of apparatus and chemicals by the learners themselves put the laboratory into an initial state of chaos. However, order replaced this initial chaos as learners started on their procedures. Andres would move around, trouble shooting for those finding challenges mounting a burette or using a pipette. At times when he found the need, he would call for everybody's attention so that he could address an issue, may be a common mistake that most learners were committing.

When learners finished the experiment, and were recording their results they cleaned up, placing burettes and pipettes on the side tables. Used chemicals were placed at their own table. Retort stands were dismantled and placed in the storeroom. When learners had cleaned up their workplace they were ready to leave. This was the last school period of the day and they had surpassed the time anyway. It felt as if the learners knew the order of doing things in Andres' laboratory. Completed laboratory reports were to be submitted the following day.

Interviewing Andres

During interviews, Andres revealed an overall positive attitude towards CAPS. On being asked how he viewed the changes from NCS to CAPS, he said:

...I think there are definitely some good changes maybe in terms of content, if you were in NCS there were certain content material that was not linking the grades together so now with CAPS you can observe that there is a goal because you can see in the grade 12 syllabus there is grade 10 work being examined and so forth so I think it has formed more a step...

In his response to this question, Andres does not cite personal concerns but instead seems to focus his attention on improvements in curriculum coherence. Andres voices his approval of CAPS when he singles out acids and bases as an example of new topics that are relevant in better preparing learners for tertiary education. He says:

...I am just thinking of when I was in first-year university those are also the things we started with. The syllabus that we are doing now is very relevant to what is done first year at university level...which makes that transition also a bit easier...

For Andres, support from the subject advisors has assisted teachers with content on new topics that is not available in textbooks. Subject advisors constantly make that content available to all physical sciences teachers through a communal online "blackboard" apart from occasional meetings. He articulates this as follows:

...what assists us is that the subject advisors prepare some material and then when you look in that material then it's helpful...

Andres complained about time constraints which in his own perspective are because of the large content to be covered. He says:

... The syllabus it's packed to an extent that now its excluding the grade 11 work that they also need to know; the grade 12 syllabus as well on its own is also quite a bit hectic...I think some things could be removed...

This shows a teacher under immense pressure considering that he also works part time at a local university. This also confirms the stages of concern findings that revealed his highest peak at the management stage of concern.

Andres, who majored in physics only and works part time at the local university, is concerned about how his own deficiencies in chemistry content knowledge impacts his learners. He openly articulates this issue when he says:

...I mean all of us we have got our own strengths so you'd prefer physics because you are more comfortable with the physics content while someone else would prefer chemistry so and you can pick it up also if you look at the children's marks you can see the kids are doing good in this but they are not doing so well in that so you can immediately see because a teacher influences the kids as well...

When I asked Andres about his role as a teacher and his teaching approach, he stated his conviction that a learner-centred approach is the best approach but he also thought there was little time to do that and that is why most of his teaching is teacher-centred. He adds:

...because sometimes you are told let's say to become learner-centred but things like time also influence because the moment you see that time is limited then coaching takes a lot time then you push that aside then you start teaching...

Although the teachers interviewed in this study seldom articulated their needs in terms of pedagogical content knowledge (PCK), Andres expresses himself in a way that one could conclude that he was referring to PCK. He said:

...I think the department must still allow for our subject advisors... if not them... to bring more experts in order to give training on certain content in different approaches because sometimes the approach that I use doesn't work for them. We don't all learn the same; we are all individuals so the way I understand is not same way someone else understands. Sometimes it's very nice especially with the content workshops to see how someone from another school is approaching a problem and it gives you a different

perspective, so definitely on the content workshops...yes, with the new topics...

Andres confirms that he faces challenges in terms of time management and he states that the employment of laboratory assistants could help solve these challenges. He comments as follows:

...if schools could have laboratory assistants...like at university... to assist science teacher...eeh the experiments could be done well to assist learners. It would help with the organisation and the cleaning ...the teacher could dedicate more time to teaching...

The observations and interviews seemed to confirm Andres' relative intensity profile. Observations and interviews seemed to confirm that he contends with time constraints. To mitigate his shortcomings in SCK and PCK especially in chemistry topics Andres uses a variety of sources of information including notes, worksheets, templates for laboratory reports from the subject advisors and the University of the Free State schools partnership programme. To cope with the need to keep up with the stringent time frames on the work schedules and the 'increased content' under CAPS, Andres had resorted to teach outside normal school hours.

4.4.3.2 Karabo

When I interviewed him, Karabo had been teaching for 14 years in the same school. He obtained a B.Sc. in chemistry but at the beginning of his career was restricted to teaching at the GET level. After six years, he was "promoted" to teaching in the FET level and four years after that he taught grade 12 for the first time although he was restricted to teaching chemistry topics while a second teacher taught physics. After two years of this arrangement, he was tasked with teaching chemistry and physics topics as the only teacher responsible for grades 11 and 12 physical sciences. In that same year, he began a long-distance course on physics teaching with a South African university, attending classes on a block release basis.

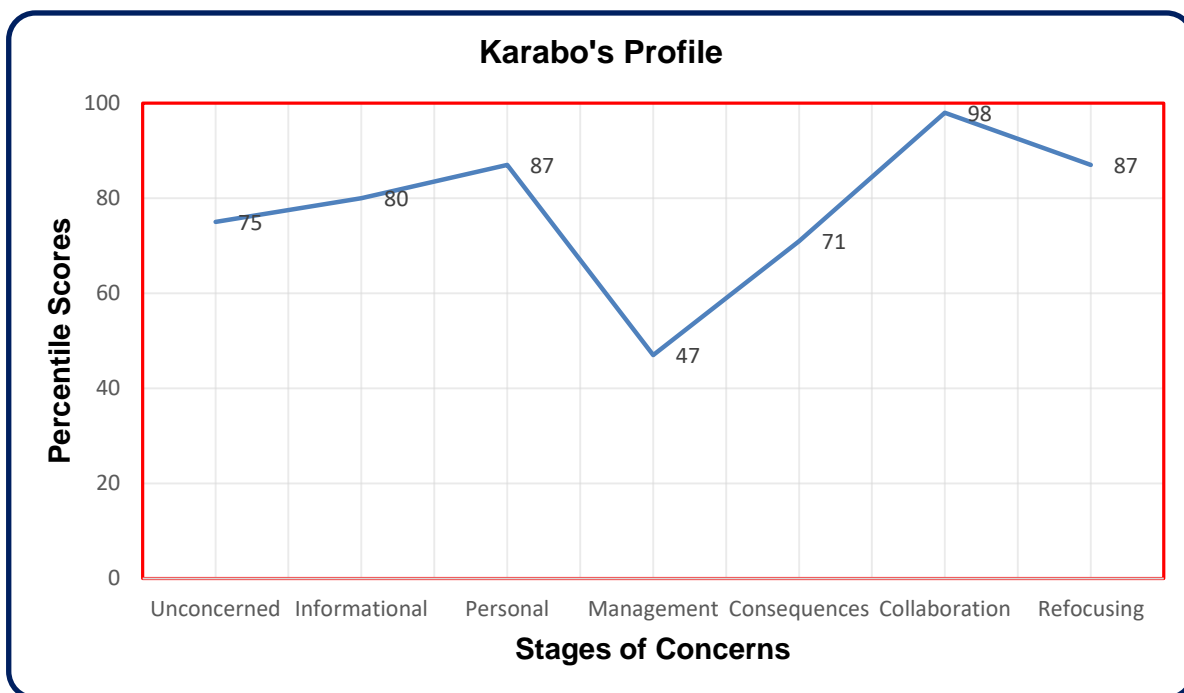


Figure 4.7: Karabo’s individual relative intensity profile

Karabo’s profile (figure 4.7, above) is highest at the collaboration stage (98) indicating that his concerns are most intense regarding working with others to make CAPS work for him, for others and for his learners. Time management, logistics and other managerial issues are not particularly significant concerns to him, as he scores lowest on the management stage (47). The (joint) second highest peak at the refocusing stage (87) is adjacent to his highest peak score, which may suggest that Karabo had already started to think about ways to improve CAPS implementation.

Observing Karabo’s lesson

When I visited Karabo for observations, he had just completed teaching acids and bases and was using examination question papers to revise the topic with his learners. I was handed two questions upon my entrance into the class (Appendices K and L). He quickly advised me that the first question (Appendix K) had been given as homework the previous day while the second question was to be done in class on that day. After the greeting and pleasantries, Karabo quickly checked if everyone had done and completed the homework. Three learners volunteered to write their answers on

the board as if the class already knew the drill. When the teacher asked the class if the three responses were correct, most of the learners agreed in chorus as they marked their homework.

For one particular question, a learner also volunteered to work it out on the board. When he appeared to have made some mistake, another learner was called to correct the mistake. While learner participation was good, as they seemed engaged, I thought opportunities were often missed to enquire why learners had made certain decisions, including the learner who had made mistakes. This revision and marking of the homework took approximately 25 minutes.

In the second part of the class, Karabo gave out the second question (Appendix L) and oriented the learners to do all the sub-questions under 7.1 as individuals and then proceed with 7.2 and 7.3 in pairs. The teacher then proceeded to move around observing what learners were writing. He would occasionally engage a learner. When two learners next to each other were done with 7.1, they would proceed to discuss and write their answers to 7.2 separately. For any form of “dispute”, the learners would raise their hands for the teacher’s attention and the teacher would engage them in discussion. I found Karabo’s approach quite effective in the second part of his class. Sometimes during these paired discussions, Karabo would answer a question from the learners by asking a question back in a clear effort to make them think on their own. Below is one such an exchange:

To respond to sub-question 7.2.1, two learners had written the formula

$$pH = -\text{Log}[H_3O^+]$$

After substituting, they had written down the following equation:

$$0 = -\text{Log}[H_3O^+]$$

However, they were unsure how to proceed; therefore, the conversation continued as below:

Learner A: Sir, we are not sure how to proceed from here, on question 7.2.1

Karabo: Let’s see (Pause)

Karabo: Okay, are you sure you don't remember this...we have done a similar problem before...

Learners B: (Sighing)...We tried sir....

Teacher: Okay...on your calculator what do you do to remove the log? What is the inverse of log?

Learners: (Looking at their calculators)..okay...

Learner B: (to A) Keo jwetsitse!... (meaning I told you)

Learner A: okay so we use ten to the power something...

Teacher: Yes...but how..

Learner B: We take 10 to the power of both sides after dividing by minus one on both sides....

Learner A: but minus zero is still zero.

Eventually the learners write two steps to get the correct answer

$$10^0 = [\text{H}_3\text{O}^+]$$

$$[\text{HCl}] = 1 \text{ mol.dm}^{-3}$$

The first part of Karabo's class appeared routine and predetermined and showed little evidence of the presence of learner thinking. However, the second part revealed evidence of learners being encouraged to think by the teacher. Learners also engaged each other and constructed knowledge in a social setting that, at the least, appeared democratic and in which their voices were recognised.

A glimpse into Karabo's laboratory practices

The experiment on Esterification (formation of esters from a reaction between an alcohol and a carboxylic acid) in Karabo's laboratory was with fourteen grade 12 learners in pairs, forming seven experimental stations. The orientation involved drawing structures of esters and deducing the alcohol and the carboxylic acid from which it is formed. One example was given in which an alcohol and carboxylic acid

were specified from which learners had to name the esters that would be formed. The worksheets with the experimental procedures (Appendix M) were distributed to each learner. Thus, although the learners were working in pairs, eventually each one would write up their own laboratory report, which consisted of completing the worksheet. The teacher suggested that each learner should practise being 'hands on', as there were two experiments so each learner could actively lead one.

Most of the apparatus and chemicals were distributed around the laboratory on the side tables. Karabo had two male learners who acted as his assistants. When something was missing from the side tables, these two were the ones who would be sent to fetch the missing chemical or apparatus from the adjacent storeroom and they were quite efficient. Oftentimes, learners would ask for missing apparatus from these 'assistants' rather than calling upon the teacher directly. In between assisting other learners, this pair (they were working together at the same experimental station) would work on their own procedures.

The proceedings were orderly. Karabo would move around from pair to pair, assisting where needed. As time went on, the laboratory was filled with the "sweet smell" of esters and it was as if the laboratory could have been better ventilated. This drew my attention towards laboratory safety. Despite the use of concentrated sulphuric acid, no learner had eye safety glasses or a laboratory coat. Neither did the teacher mention anything about safety, especially the dangers of volatile ethanol to anyone pregnant (there were eight girls in the laboratory).

Most pairs finished the experiment on time and proceeded with answering further questions related to the experiment. When time was up, everybody had completed the experimental part but a few had not completed the questions. They were given more time to complete the questions and hand over their worksheets to the class representative the following day. The class was then dismissed.

Interviewing Karabo

During interviews with Karabo, I sought to explore the tentative findings of the stages of concern results further. I also wanted to explore the results from the observations.

When I asked Karabo whether he thought it was necessary to change from NCS and introduce CAPS, his attitude about the change is positive and approving. He responded as follows:

...maybe they have realised that NCS was not working properly and we also believe so that it was not working properly because there were something that they have to be changed...

When I asked him what he thought were some of the advantages of CAPS over NCS, Karabo relates his personal experience as a first year chemistry student when it was challenging for him during practical classes, as he had no prior experience with experimental work. He said:

Yes, remember on first year level university you also have to do those titrations and if you can't even mix those things together then you stay behind in the classroom for about a week not being able to titrate...

Karabo stated that CAPS was also addressing some of the assessment challenges that characterised NCS.

On responding to a question on how CAPS was different from NCS in terms of practicals, Karabo becomes more specific, revealing his grasp of the changes in terms of practicals, by referring to the skills that need to be developed in learners.

...It [the practical recommendation] emphasises the point of twelve skills that we have to treat on each formal practical of which those skills they also cover every learner...

Karabo, who only majored in chemistry, points out that it would greatly assist teachers such as himself if there were more workshops on the new content when he said:

...It's also going back to saying we are not perfect all of us, if we can be able to bring on those teachers' development regularly ... it's not going to help us.... Teacher development means that it has to be content...especially in the new topics...

On probing Karabo further regarding what topics he needed assistance with, he mentioned Big Bang theory, acids and bases, polymers, Newton's laws, emission

spectra and the Doppler Effect. What becomes more interesting is that although he mentioned some new sub-topics in chemistry, he also mentioned physics topics previously included in NCS, raising the probability that he might already have been struggling with teaching these concepts before CAPS because he majored in chemistry.

About titration experiments, Karabo shared his experience as a first-year student at university. He lamented that his experience as a chemistry student was challenging because he lacked titration skills which were part of the first-year curriculum for chemistry majors at the university he attended. He, therefore, welcomed the inclusion of titration experiments at grade 12 as he supposed that some of his learners would probably be at an advantage if they proceeded to study science programmes at tertiary institutions.

In Karabo's case, not only did he understand the topics but he also understood and appreciated their importance to his learners. Such a teacher is most likely to be motivated towards bridging the gap between what they know and what they do not know. When I directed the interview towards the practical emphasis under CAPS, Karabo quickly pointed out the 12 practical abilities articulated under CAPS.

Referring to how the authorities can assist in the improvement of teachers' content knowledge, Karabo suggested more workshops directed at subject content.

... Teachers have to group themselves, the department has to hold those workshops for teachers on content; bring all universities online assisting educators in terms of teachers' development. I think if they have to lose lots of money on teacher development...

Karabo suggested using technology and workshops to improve teachers' knowledge domains. He suggested that teachers could also be organised into clusters where they discuss content that is proving challenging.

For Karabo, arguably the most positive teacher among those interviewed, access to an excellent textbook would help to reduce his unfamiliarity with the physics content and may reduce the need for teacher development aimed at content development.

According to sources at the department, the science centre which was in Bloemfontein closed around 2014. In response to this Karabo said:

...I think the department has to go back, if you check we don't have science centre anymore. If they could go back to the universities and open those science centres to the nearest universities and FET colleges then it could help them to save a lot of money in terms of the practical experiments...

Conclusions on Karabo's overall profile

Karabo's intensity profile revealed that his greatest concerns were collaboration and refocusing. These are higher stages of concerns. Karabo was generally receptive of the introduction of CAPS. Having majored in chemistry only, Karabo recognises his insufficiencies to teach physics effectively. He called upon the Free State Department of Education to put more resources towards teacher development so as to improve teachers' content knowledge in the physical sciences. His classroom practices blend traditional and constructivist approaches. Karabo did not seem to struggle with time management, confirming the results from the stages of concerns. His score on the management stage of concern was the lowest. The reason could be related to his classroom management. His treatment of revision with question papers seemed precise and effective.

4.4.3.3 Thandie, another negative one-two split profile

Thandie had been teaching for four years after obtaining an honours degree in pure chemistry. Initially, she was teaching mathematics to grades 8 and 9 but after two years, she started teaching physical sciences to grades 10 to 12. Currently she is the only physical sciences teacher and teaches physics and chemistry topics, despite her lack of tertiary preparation in physics. Furthermore, Thandie does not have an education qualification. She is one of several teachers from her school who commute the 70 kilometres from Bloemfontein every day. When she had to attend workshops organised by the Free State Department of Education, Thandie would not go to school for that day even if the workshops were arranged to begin in the afternoons. Below (Figure 4.8) is Thandie's relative intensity profile

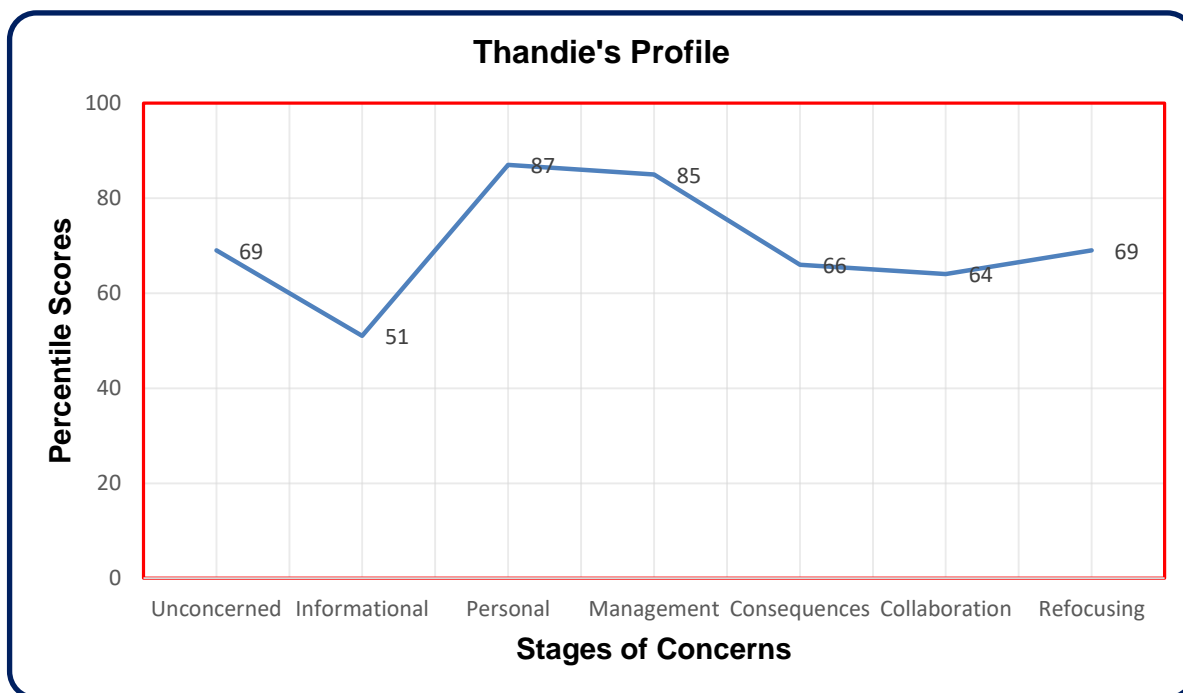


Figure 4.8: Thandie’s individual relative intensity profile

Thandie’s profile showed the highest peak at the personal stage of concern. This suggested that she might be most concerned about how CAPS affects her on a personal level. This is a typical “negative one-two split” profile. It has a large difference between stage one and the highest peak is at stage two. Such a profile suggested that Thandi might have various degrees of doubt and resistance to CAPS (George *et al.*, 2013). It is also possible that in the background there were personal issues acting as obstacles for her to have the desire to implement the current innovations. Until such concerns are addressed, Thandie is unlikely to cooperate with the implementation of CAPS. The observations and interviews that followed sought to confirm or refute these suppositions.

Two classroom observations were conducted on Thandie; a laboratory experiment on electricity and a class lesson on emission and absorption spectra for grade 11 and 12 respectively.

Thandie’s class

When I entered Thandie’s class, she had approximately ten minutes before her grade 12 lesson. She told me that she was almost done with the photoelectric effect topic.

She was only left with treating the content on absorption and emission spectra then she would be finished. She showed me her notes, which had the following objectives.

Emission and absorption spectra

- ✓ Explain the *formation of atomic spectra* by referring to energy transition.
- ✓ Explain the difference between *atomic absorption spectra* and *atomic emission spectra*.

When the grade 12 class entered, she went on to introduce the sub-topic and wrote the following definitions on the blackboard as the learners copied into their notebooks.

An atomic absorption spectrum is formed when certain frequencies of electromagnetic radiation are passed through a medium, e.g. a cold gas, is absorbed.

An atomic emission spectrum is formed when certain frequencies of electromagnetic radiation are emitted due to an atom's electrons making a transition from a high-energy state to a lower energy state.

This was the end of this part of the syllabus. She had completed the part on the photoelectric effect. However, in my opinion, she could have reinforced learners' understanding through a simple diagram; for example, (see Figure 4.9 below) and briefly outlining the implications of this spectrum.

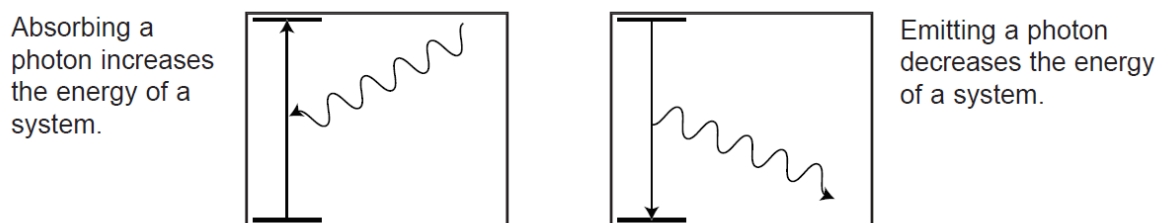


Figure 4.9 Diagrammatic representation of Absorption and Emission of a photon
(source:<http://www.smallscalechemistry>)

Thandie could have added that when a photon is absorbed an electron *jumps* to the next electronic level above. When an electron “drops” from an excited state to a lower

level, it emits energy. The word quantum means significant or major. An electron cannot occupy the space between the two consecutive levels. Only certain levels are permitted. Energy is thus quantised. That is why it is called quantum physics.

The application of the emission spectra to identify certain elements (as each element has its own unique spectrum) could have been cited. Mentioning the phrase “quantum physics” or the name Max Plank could have added interest and made science appear more like a human endeavour that is ever evolving.

When I later asked why she had been so brief on this part of the syllabus she explained that this section did not usually appear in the examinations and if it ever does, it does not count many marks.

The part of emission and absorption spectra represented the end of the photoelectric effect topic for Thandie and her learners. It was then time to look at the type of examination questions that learners could expect, hence some handouts were distributed. A brief orientation was given, and learners started writing their answers in their classwork books. The period ended before they completed the questions so the task was translated into homework.

Observing Thandie’s laboratory practices

The laboratory experiment was presented as a group experiment to a grade 11 class of 32 learners who were grouped into six groups of five learners. When I entered the laboratory a few minutes before class commenced, Thandie was just finishing setting up the learners’ workstations. The storeroom, which I took a quick glance into, looked disorganised with old and disused equipment and chemicals. When learners entered, Thandie gave a brief orientation to the experiment and distributed one set of the experimental instructions with the procedures per group. Each student was given his/her own experimental report template to complete, which was due the following day. Thandie called the whole group to approach the teacher’s table as she demonstrated some of the procedures before sending the learners to their workstations. Although she gave a good orientation of the experiment, there was little evidence of an inquiry approach. Learners simply followed predetermined procedures. Thandie efficiently moved from group to group, assisting learners through the procedures. In one group, there was a shortage of cells, so this group took over the

teacher's table. Towards the end, the class had become disorderly and noisier, with Thandie becoming busier, alternating between troubleshooting experimental workstations and shouting at the learners in an attempt to maintain order. By the time the two periods had elapsed, half of the groups had managed to complete the experiment. Thandie concluded the class by advising those groups who had not completed the experiment to come at the end of the school day to complete it and warning them to be early as she only had an hour before her transport departed for Bloemfontein. When the learners left, a new class entered the laboratory and this class had to help Thandie clear up.

Interviewing Thandie

When I asked Thandie what she thought about the introduction of CAPS to replace NCS, she responded as follows:

No...the introduction of CAPS was not a good idea, I am saying that because the organic chemistry started in grade 11 and it was easier for me to go through with it to grade 12 but they removed it in grade 11 since CAPS.

Thus, Thandie cites personal concerns for her disapproval of CAPS, confirming findings from the stages of concern questionnaire, which indicated the personal stage as her highest concern.

When quizzed on whether it is challenging to teach chemistry and physics topics when she majored only in chemistry, she responded:

...In some topics... because some topics I can't give them the way I want to...

Thandie indicated that there is plenty of pressure to produce "good" results, especially for those teaching grade 12 classes and she says:

...all they do is talk talk...we need 100 per cent, we need quality results, we need 100 per cent quality results, but it is not happening...

I need to learn how to carry out those new experiments especially in physics because even...uuh...even though there are new experiments in chemistry I can always improvise because... Eeh...as I am from a chemistry background... I can jump into the

storeroom without much preparation and get chemistry experimental apparatus and quickly set up a chemistry experiment with little difficulty but physics...tjo!!!...I struggle...

Seemingly, Thandie is similar to most teachers (92.2%) who took part in the survey questionnaire of this study and who are responsible for teaching chemistry and physics topics even though they only majored in chemistry and physics. Physical sciences teachers' challenges in practical work, even in subjects they have majored in, is well documented (Mizzi, 2013; Barnea, Dori & Hofstein, 2010) and can only be magnified when teachers have not majored in one part of the two physical sciences sections, especially during times of curriculum reforms when new topics and experimental requirements are introduced. When I asked Thandie if her teaching had become more learner-centred or more teacher-centred she seemed confused:

...Learner-centred? I don't know... what is that?

When I clarified to her what learner-centred and teacher-centred meant she added:

...To me it's still the same, I don't know. NCS we were doing the same thing...

I asked Thandie whether she prepared the handouts and worksheets she used for her class to which she replied:

...No...Not really. I get them from some colleagues and some I get them from the subject advisor...But sometimes I just modify them a little bit to suit my objectives but in most cases they are good enough just as they are ...

Thandie seemed indifferent about the introduction of CAPS. She cites the new sequencing in topics coverage, which was not convenient for her teaching style. Thandie admitted challenges in teaching some of the new topics especially those in physics. She added that preparing for physics laboratory is challenging to her, as she was not a physics major. To mitigate some of these challenges, Thandie made use of notes, worksheets, and laboratory reports templates she sourced from colleagues and subject advisors.

4.4.3.4 Siyanda

Siyanda had been teaching for 16 years and had been engaged with CAPS from the beginning (2012). She has an honours degree in physical sciences teaching, and

teaches chemistry and physics topics. At the time of the interviews, she was also studying towards a Master’s degree in science education. Siyanda revealed that she enjoyed teaching physical sciences, as she knows how to teach the subject and thought she was positively influencing learners through her teaching. Her profile is shown below in Figure 4.10.

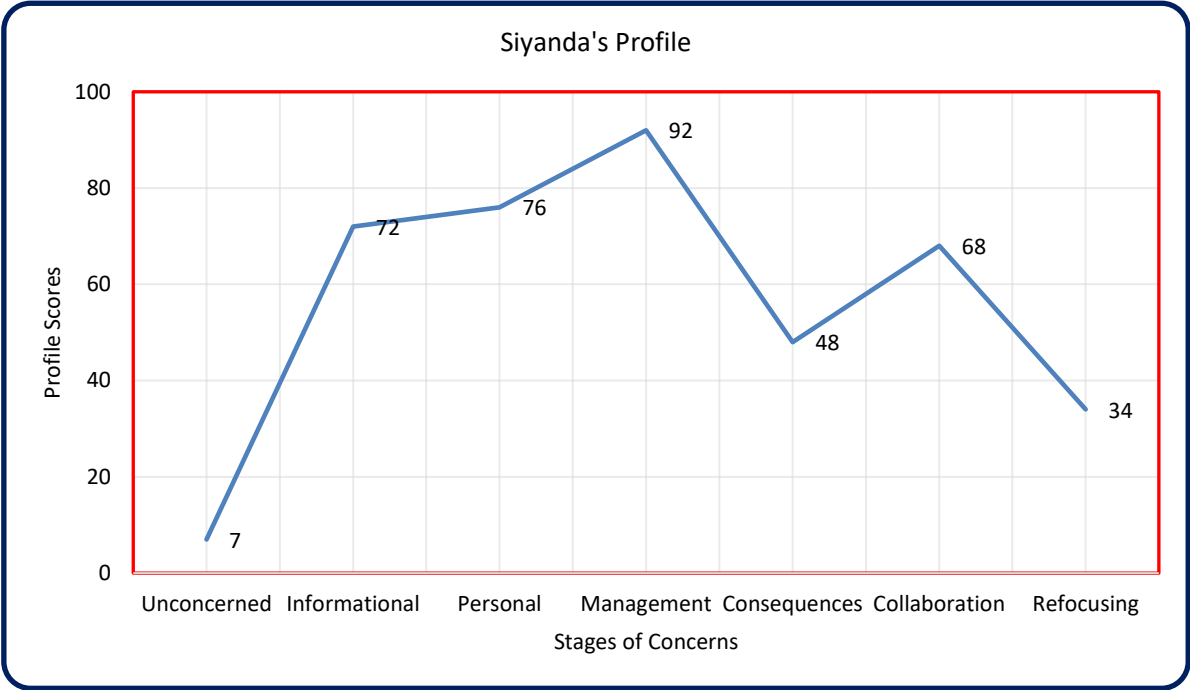


Figure 4.10: Siyanda’s individual relative intensity profile

With the highest peak at the management stage (92%), Siyanda is mostly concerned about time, logistics or other managerial problems related to the efficient use of time (George *et al.*, 2013). Siyanda also has some intense personal concerns (76%). The informational (72%) and the collaboration (68%) stages ranked third and fourth highest. For her, the highest peak and the second highest peak are adjacent to each other, suggesting progression. The unconcerned stage scores the least (7%) which is a deviant from the average of the group, as the group cohort has the unconcerned stage as the highest peak (96%).

Siyanda’s profile was of interest for several reasons. Firstly, her lowest score was on the unconcerned stage when the whole cohort scored highest on that stage; secondly, her enrolment for a Master’s degree at the time of this study; thirdly, the adjacent nature

of her highest and second highest peaks suggesting that her implementation of CAPS is progressing from lower level to higher level concerns.

Siyanda's class

Although she was expecting me to come and observe one of her lessons, the day I observed Siyanda's teaching I arrived unannounced. As we waited for her grade 12 learners to come into her laboratory (which doubled as a science classroom), she gave me a copy of the handout notes prepared for the learners. She briefly confided in me that it was a bad day to be observed, as she was not in a good mood because her learners had performed poorly in a test two days previously and she was going to give them back the scripts that same day. The test was based on organic chemistry definitions.

The class started with a quick revision of the test. In most cases, limited time was allowed for the learners to respond and write corrections. In some cases, Siyanda would end up answering the questions herself and move on to the next question. Below is an extract of some exchanges:

Siyanda: Okay...now what type of polymer is this? Anybody who knows? ...It's an addition polymer, isn't?

Learners: Yes ma'am...

Siyanda: okay can somebody tell me...what is the definition of addition polymerisation? I told you to use your examination content book...know all those definitions...anybody? What is addition polymerisation?
(Learner A raises her hand up)

Siyanda: Yes...Sohuma?

Learner A: (seemingly reading from her book)...a reaction in which small molecules join to form very large molecules by adding on double bonds.

Siyanda: Good...I have told you to memorise all those definitions. They will be there in the exams...but most of you don't listen...Okay now...

I could understand Siyanda's frustrations in the context that her learners had performed below expectations in the previous test but her apparent frustrations were not helping her cause. The class was so tense I am sure if any learner had questions to ask they would certainly not have dared.

After the revision, Siyanda shifted to the day's lesson, which was about condensation, polymerisation and identifying monomers in a polymer. By then the mood in the class had improved. Mostly, the class involved Siyanda writing the notes on the board and the learners copying them into their notebooks. Siyanda would pause as she waited for the learners to catch up. In between the pauses, she explained the notes.

After the notes, she went on to draw three examples of addition polymers and exemplified how to deduce the monomers. Some learners asked questions for clarification and Siyanda responded by giving them answers. Siyanda was the centre and the authority in the class; this was not left to anyone's imagination.

After the learners had copied the examples down, Siyanda erased them from the blackboard, wrote down three more polymer segments and asked the learners to write into their classwork the names of the monomers that formed them as well as to draw their structural formulae. As the learners worked, Siyanda paced around the class, checking proceedings and making occasional comments. Siyanda's exchanges with the learners had some evidence of an inquiry approach, as is exemplified below:

Siyanda: [pointing to a structural formula a learner had drawn as the monomer] How did you get this?

Learner B: I realised the repeat pattern...

Siyanda: And then...?

Learner B: Then I identified the repeat unit which...

Siyanda: Which one is the repeat unit here? Then what did you do?

Learner B: This is the repeat unit... I then added a double bond to the repeat unit, like this to get the monomer.

The rest of the class followed this pattern as she continued to move around the class, sometimes marking and asking how the learners had arrived at their answers.

Observing Siyanda's classroom practices

Siyanda's grade 11 class was going to do an experiment on the titration of a solution of hydrochloric acid with a standard solution of sodium hydroxide. No worksheets were handed to learners for the activity. The class of 37 learners was divided into two groups and they occupied different ends of the classroom. When the class entered, she had already set up the apparatus and chemicals as two experimental stations. She had to do two demonstrations and each group had to crowd around their workstation.

Siyanda gave a brief orientation on the blackboard, mentioning a few important aspects, including safety. After which she went on to demonstrate to the first group. During this time, she would alternate between following the procedures that were outlined on the worksheet, explaining to the group what she was doing and shouting at the other group who were at that point doing nothing except waiting for her to finish with the first group. After finishing the titrations with the first group Siyanda distributed some worksheets to the first group that they had to work on while she demonstrated to the second group.

Interviewing Siyanda

In response to whether she felt the need for change from NCS to CAPS, Siyanda said clarity makes CAPS better than NCS. Thus, the challenges she faced under NCS had been resolved in the new reforms.

She further commented:

...we as teachers were confused [under NCS] ...CAPS is more organised ...it's more... (pause)...everything is clear...so there was a need [to change] ...there was a lot of confusion with the NCS...

Such perspectives would impress the policymakers, as they specifically sought to achieve clarity with CAPS.

For Siyanda, the clarity in what teachers are supposed to assess on a daily or weekly basis has made her work easier. On being asked what she considered the most significant differences between CAPS and NCS, she emphatically responded:

Assessment...in NCS the assessment was not clear. It was not clear how I was supposed to assess the learners. Yes ...and ...how to manage the topics...yes...but now [under CAPS] the assessment is clearer...I know when to give a test...how long the test should be...where to get the information...

The changes concerning practical experimental work were also some of the reasons for the positive opinions of most teachers. UMALUSI (2014) highlights that there has been a set of recommended practical experiments that learners must have hands-on experience of and that a set of clearly defined practical skills have been spelt out at each FET grade. On the new changes, Siyanda pointed out:

Um.... the positive about these changes are that the practical experiments are included. Before...the practicals were not that stressed but now they are included in grade 10, 11 and 12. And learners must have them, they must have those skills. They must have the demonstration skills, the handling of data...all those... identification of all those variables...independent and dependent variables. So, that is an added advantage. Ah...that's the main advantage...

For Siyanda, departmental support through subject advisors has been sufficient, as she commented:

...everything is...if you just look for it and if you ask for help from people from the LFs [subject advisors] ...everything is there...Past [examination] papers are there ...we can practise. The books are there...they are always telling us to write down [lists of] books that we need, books that are missing, textbooks that we need from grade 10 to 12. You know there is a lot of support...

Siyanda elaborates on departmental assistance when she referred to the meetings that are periodically held at cluster level and important matters concerning physical sciences that are discussed with subject advisors:

...nobody should have an excuse. At the beginning of every year we have a cluster meeting whichever district you are in they, you get together with the LFs, they give you the analysis of the November paper [Examination reports] results written previously, so that you can go over it, and see what is expected of you, how you are to teach grade 12, how to mark, how to assess...the

expected past exam papers, the expected projects for grades 10 and 11. ...everything...we have been given all the information. ...how to mark and how to assess...

Siyanda complained that the prescribed textbooks had insufficient exercises and problems for learners to practise. She also complained of the errors in some of these textbooks.

"...The textbook issue is a big issue. Some textbooks do not have a lot of questions. Learners need to exercise through answering questions. They keep on changing textbooks. Study and Masters is very good but has few exercises...such as Olivier has got nice exercises. The three in one was got but they are few of them.

Siyanda's tone betrayed deep-seated frustrations regarding administrative work, which she said interrupted the smooth running of her classes, as she was frequently asked to provide numerous statistics at short notice, even during lessons:

...The only problem is that there is too much administration... but every other day they would ask us the same questions about the textbooks...how many textbooks are you short of? We want the information now! How many boys do you have ...all that is administration...how many girls do you have doing science in your class? Sometimes you have to leave your class and go and fill in a form about such information repeatedly throughout the year.

Siyanda felt that training for the practical experiments was insufficient:

...remember when CAPS was introduced they told us there will be experiments but they did not tell us how to do the experiments, although we have done them at tertiary level, a lot of things have happened, some of us may have forgotten those experiments we learnt at university. So CAPS is a good idea but they did not do everything, they did not train us in other aspects like practical work...

The emphasis on results, especially matric results, became evident as more in-depth analysis was carried out on participants' responses. A picture began to emerge of a workforce under pressure to produce. Siyanda, almost pleadingly said:

...The assistance will be with slow learners...we need assistance...because no matter how you teach mixed classes with slow learners. They should not expect everybody to pass. It's like a race, you cannot expect everyone to come out on top in a race....some are certainly going to be left behind...so we need assistance so let them come and show us how to make the slow learners pass because they say it is possible to make even those very slow learners to pass. So that would be very nice for them to come and demonstrate to us how to achieve that...

Some of the most significant changes in physical sciences are the recommended practical experiments in the chemistry and physics sections (UMALUSI, 2014). Siyanda confirmed the challenges she faced in carrying out the practical experiments with learners. She confessed that resources might be available but sometimes she was unable to use them:

...In my school we have the Shanduka project...the Kagisho Shanduka project. So we get resources from there. But at the same time they need to unpack the resources, they need to bring the manuals and tell us how these things work, where they work, which experiments are for what, because the box will lie, it will not be opened, time goes and you ask somebody please come and explain how to use this, for which experiment. You wait for that person, you try to get the things, to do it yourself, but then the time is going. So usually, yes the resources are there but we may not use them because...[t]hey did not tell us how to do the experiment...

Siyanda's description of resources that exist but which are not being used because the teacher is insufficiently skilled could be widespread.

The lack of sufficient experimental skills, which adds to time pressure, is clear in Siyanda's case as she often found herself waiting for someone to come and unpack a box full of resources; Siyanda would not open it herself as she felt she would not be able to use the resources. Furthermore, time would be required to contact teachers in neighbouring schools to organise a demonstration. This kind of collaboration between teachers is often done outside normal teaching hours and may add stress.

When I asked Siyanda why her teaching was mostly teacher-centred, time pressure was a factor in her response:

...There is no time especially in grade 10... Grade 10s have many topics... in the first term [and they come from grade 9]...so if you try a learner-centred approach I feel, that... as I have tried it before, I noticed that they are from grade 9 where they do the group work and other learner-centred approaches but if you try it in grade 10 it wastes a lot of time, one is not able to cover [the content syllabus on time]...

Siyanda also mentioned that she could not carry out some of the experiments with her learners. When I asked her to explain, she responded as follows:

...Usually it's time...there are time constraints, you cannot do that...So you can only do the demonstration and sometimes you can only give learners some worksheet on the experiment to practise and then they will have the answer...

The poor quality of the available textbooks has been cited above as one of those aspects generating negative perspectives about CAPS from teachers. Siyanda captured this sentiment when she said:

...The textbook issue is a big issue. Some textbooks do not have a lot of questions. Learners need to exercise through answering questions. They keep on changing textbooks. Study and Masters is very good but has few exercises...So the textbooks are available but you need to choose carefully...Some textbooks have errors in them...

When I enquired about the notes she written on the board, Siyanda said most of the time she prepared the notes from textbooks and materials from the subject advisors. My observations on Siyanda's teaching practices and the subsequent interviews shed some light on how she was implementing CAPS. In her opinion CAPS had more clarity on assessment and teaching objectives. Though she spoke freely about the advantages of CAPS, she also had some unfavourable reviews on the reforms. Among the challenges, she was confronting were: insufficient practical skills, time constraints and administrative work.

4.4.3.5 Thabo, a 'new' physical sciences teacher with a negative one-two split profile

Thabo was a young teacher in his first year as a physical sciences teacher, having graduated from a local university two years prior. The department had last rolled out its workshops for preparation for CAPS two years previously thus Thabo had missed the preparation. I selected him for the interview because he represents those teachers who are new in the system and have missed these workshops for preparation for the new reforms; as such, they form a 'blind side' to the policymakers. His intensity chart is below (figure 4.11).

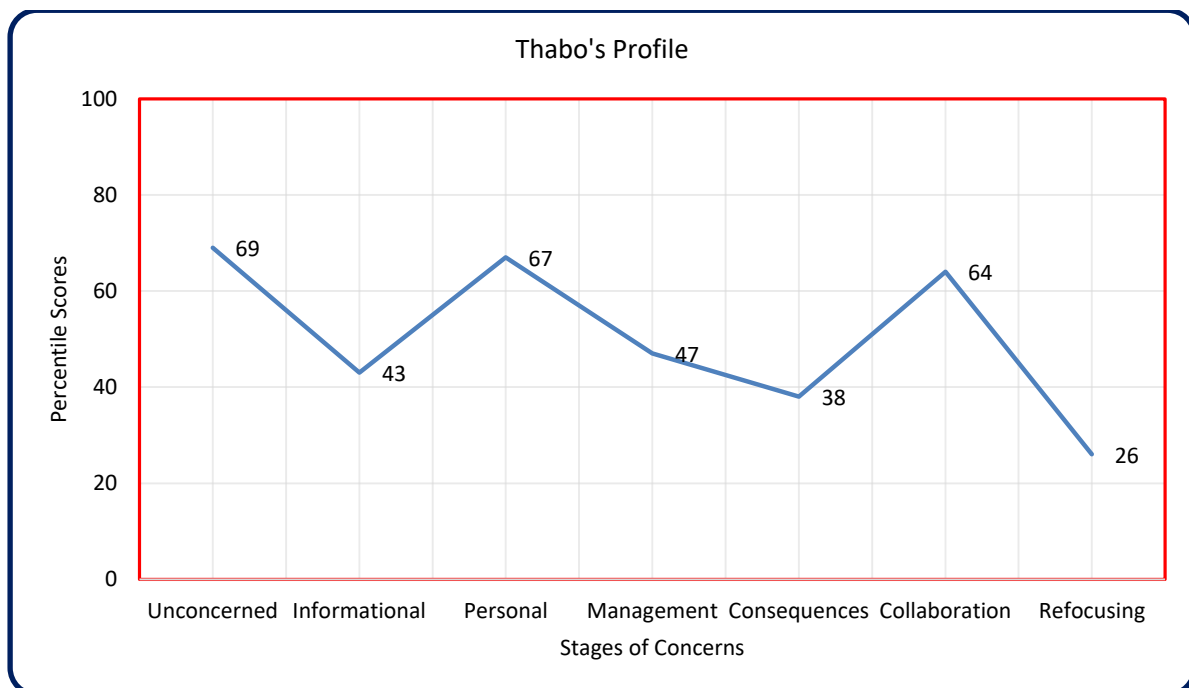


Figure 4.11: Thabo's individual relative intensity profile

Thabo's profile has a multiple peak profile with the highest peak at unconcerned (69%), the second highest peak is at the personal stage (67%) and the third highest peak at the collaboration stage (64%). The highest peak at the unconcerned stage indicated that CAPS was not the only thing occupying Thabo's mind; there may have been other initiatives, tasks and activities concerning him, possibly personal (second peak). This profile is an example of a "negative one-two split" profile where stage two is distinctly higher than stage one. Such a profile indicates Thabo's uncertainty regarding the reforms and possible resistance towards CAPS implementation (George *et al.*, 2013). Individuals with such a profile may not easily consider an innovation until their personal concerns (stage one) are addressed. The interview was modified in order to probe how

it was for a new teacher joining the system, after the department had completed its workshop and training delivery and to fully comprehend why Thabo had peak scores at the unconcerned and personal stages. I also sought to understand why Thabo had a dip at the information stage when he is new in the system and has probably missed plenty of information, especially as he had not attended any preparatory workshops and training on CAPS. An understanding of Thabo's concerns could highlight the apprehensions of new teachers as well as inform the authorities on how best they can formulate strategies to enhance implementation from teachers such as Thabo.

Observing Thabo's grade 10 class experiment

The first observation for Thabo was announced, it was a practical experiment with his grade 10 class of 43 learners. He was quick to hand me the same worksheet he was going to issue to each of his learners as they streamed into the laboratory. The learners were organised into groups of about six, each group at their own workstation. From each workstation, a leader was selected to handle most of the procedures. The lead learners were also tasked with collecting equipment from the teacher's table: cells, circuit boards, wiring, resistors, ammeters etc.

The procedures were carried out with Thabo barking instructions for the whole class to follow at their workstations. He alternated between this mode and moving around to observe if learners were making the right connections, as per the worksheet. Considering the size of the class, Thabo managed the class very well.

The lead learner was also tasked with selecting one other learner who helped with the reading of the results to complete the results/observation table. The learners were required to complete the table individually, after which they would respond to the questions, which were also displayed on an overhead projector:

1. For this investigation, write down the:
 - 1.1 Investigative question
 - 1.2 Hypothesis

The questions were quite interesting. I considered these high cognitive level questions for learners in grade 10. Thabo assisted learners in arriving at answers using the overhead project. I noticed he was, by this time, not moving around to assist learners individually or in their groups as he had done during the experiment.

When time was up, no learner had completed the worksheet so everybody was told to submit their completed worksheet the following day during their next lesson.

Interviewing Thabo

When I asked Thabo whether he thought the changes from NCS to CAPS were necessary he replied:

Yah, I think there were necessary because now physical sciences is now becoming more practical than theoretical. That's the information I am receiving from some people who have been teaching for a longer time than me.

Considering that Thabo did not have personal experience teaching under NCS the reply above is interesting; his source of information regarding the transition from NCS to CAPS is not necessarily the Department of Education, as he has missed the preparatory workshops that were last rolled out two years before he started teaching. Instead, the first source of information he cites are colleagues he interacts with at different meetings, not necessarily related to CAPS.

I pursued Thabo further on his source of information and below is our exchange.

Me: ...What kind of assistance through workshops or otherwise did you receive from the department?

Thabo: The workshop that I received last year was not a workshop actually it's the company by the name Trust; it's the one that has been mentoring me and helping me out with concepts which were a little bit a challenge.

In the above exchange, Thabo cites his second source of information regarding CAPS when he refers to a mentorship programme called Trust. Apart from providing him with information about CAPS, the mentorship programme also assisted Thabo with subject content knowledge (SCK) and possibly pedagogical content knowledge (PCK) on physics and chemistry. My follow up on Trust did not yield much except that they were an independent science and mathematics educational consultancy company providing mentorship to young science and mathematics teachers in the Free State. My efforts to establish their relationship to the Department of Education were futile.

What stood out from my interview with Thabo was that after the initial workshops, the Free State Department of Basic Education had not followed up with further workshops to assist incoming teachers with the transition to CAPS. However, in Thabo's case, other sources of information filled the gap. Thabo's profile showed a relatively low score on the informational stage (43%). Thabo's interaction with the Trust mentorship programme and with his more experienced peers could explain the low score on the informational stage.

On whether the mentorship programme had equipped him enough to teach CAPS, Thabo replies:

Yah, I can say 50% in average it prepared me the other I had to figure it out myself.

Though I was aware that Thabo had no experience teaching under NCS, I still sought to probe his perspectives on the differences between NCS and CAPS. On asking him what he considered the biggest difference between CAPS and NCS, he commented:

Kids can now be more involved and the workload it's no longer too much like previously so I think it's one of the differences that NCS had too much work that learners had to cover as compared to CAPS.

For Thabo, CAPS allowed him to be more learner-centred. He articulated this as follows:

Now learners I can easily interact with them closely and can identify which ones are having a problem and which one are in par with whatever we are busy with and then as for teachers there is less admin work than as before.

Through observing Thabo's classes and interviewing him, I learnt how a new teacher who had not attended the Department of Basic Education's preparatory workshops on CAPS was coping with the reforms. Information that stood out was that Thabo viewed CAPS as enhancing his learner centred approach in his teaching. However, I had to bear in mind that Thabo did not have any experience teaching under CAPS hence he had no point of comparison. Through interaction with Thabo I learnt that there were other stakeholders in the Motheo district who were assisting young teachers like Thabo

to cope with the teaching demands. In Thabo's particular case, Trust, an education consultancy company, had assisted him in learning more about teaching under CAPS.

4.5 Document analysis: Results and discussion

Documents provided to me by teachers, and those used in the classroom and practical experiments as worksheets were found to be emanating from different sources. The Department of Basic Education through subject advisors provided teaching materials ranging from notes, worksheets on topics, laboratory reports templates. There were other stakeholders such as The University of Free State Schools Partnership programme and Jenn Training and consultancy who worked independently or in partnership with the Free State Department of Basic Education to improve the quality Matric results. Three teachers used notes, worksheets, laboratory reports templates and booklets with question papers and the memorandums which they credited to the University of the Free State schools partnership programme. None of the teachers interviewed prepared their own worksheets or laboratory report templates.

Analysis of work schedules confirmed UMALUSI (2014) findings that a full teaching programme is provided, with the content and prescribed activities clearly described with definite timeframes. Often teachers confirmed that their lesson plans start with the work schedules which specify the week's lesson objects. The time frames on the work schedules were strictly adhered to as formal tests that are uniform to the whole province must be taken by learners on the same dates and at the same time. Generally, when teachers determine the objectives to be covered on the work schedule, they then use the examination content document (Appendix I) which are in effect brief notes on the content that will be examined. Their assessment involved using the question papers on that content as exercise for the learners.

Conclusions of document analysis

For their lesson planning physical sciences teachers generally used work schedules, examinable content documents and past examination question papers. The schedules were strictly adhered because learners had to write regular formal tests at the same date and time after completing specified sections of the work schedules. Support materials provided by the subject advisors and other stake holders such the University

of the Free State schools partnership programme and Jenn Training and consultancy. These documents were prepared at the micro level where teachers are supposed to plan and organise their teaching practices.

4.6 Motheo district physical science teachers' perspectives about CAPS

Having presented observation and interview results of the five cases selected participants, I deliberately sought to respond to research question one under a separate section from questions five and six. Questions five and six are subjects of section 4.6.

Question 1: What perspectives do Motheo district physical sciences teachers have about the changes in CAPS?

To respond to question one above, cross analysis of interview data was conducted to capture physical sciences teachers' perspectives on CAPS. In times of educational reform, positive attitudes on the necessity for the change usually indicate that the respondents are willing to cooperate to enable successful implementation (Lee & Yin, 2010; van Veen & Slegers, 2009). On the other hand, negative attitudes may indicate resistance to the implementation (Lee & Yin, 2010).

Most participants for the interviews felt that the changes from NCS to CAPS were necessary; they felt there was a need to change.

For Siyanda, the lack of clarity that accompanied NCS, which made it challenging to implement, had been resolved in the new reforms. Karabo expressed similar sentiments:

...maybe they have realised that NCS was not working properly and we also believe so that it was not working properly because there were something that they have to be changed...

Arguably, no one was better positioned than Andres to echo these views as he works part time at a local university and might have witnessed first-hand these deficiencies in first year learners. Responding to a similar question on the addition of topics in

physics as well as the cost-benefit analysis for learners Andres explains that learner would have an easier transition between high school and tertiary education, especially those who intended on studying the natural sciences at university level.

Karabo's response to whether he saw any necessity for change in the curriculum was lukewarm at first. He responded as follows:

Uh-uh in changes we believe that the system is the system, maybe they have realised that NCS was not working properly and we also believe so that it was not working properly because there were something that they have to be changed...

However, as the interview progressed, Karabo pointed out some of the advantages (for the learners) of CAPS. It emphasised practical work. He related this to his personal experience as a first year chemistry student at university. He said:

Yes, remember on first year level university you also have to do those titrations and if you can't even mix those things together then you stay behind in the classroom for about a week not being able to titrate...

Thus, the consensus was that the changes in content are beneficial to those learners who are looking forward to entering university education. This is for two reasons: firstly, the inclusion of topics such as acids and bases, which are relevant and challenging enough to allow a smooth transition from high school to tertiary level education and secondly, due to the increased emphasis on practical experiments. Deficiencies among first year university students in their basic knowledge of chemistry and physics and their practical skills have been widely reported elsewhere (Phage, 2015; Wolmarans & Smit, 2010).

Teachers also cited the clarity in CAPS, in contrast with the 'confusion' in NCS. Such perspectives would certainly impress the policymakers as they sought to achieve clarity with CAPS.

The other area of CAPS that received positive expressions from the Motheo district physical sciences teachers was the assessment. The changes highlighted by (UMALUSI, 2014) include among others, the type of questioning in the examinations. However, for Siyanda, the clarity in what teachers are supposed to assess on a daily or weekly basis has made her work easier.

Siyanda and Karabo expressed that CAPS was addressing some of the assessment challenges that characterised NCS. On this, Karabo said:

...I also think that CAPS is also addressing those problems...making sure that learners they get enough time even their questions they also being classified from low order to high order meaning accommodating all learners who have to be in that learning area...

The changes concerning practical experimental work were also some of the reasons for the positive opinions of teachers. UMALUSI (2014) highlights that there has been a set of recommended practical experiments that learners must have hands on experience of and that a set of clearly defined practical skills have been spelt out at each FET grade.

On the new changes regarding practicals, Siyanda points that developing the experimental abilities in learners had been enhanced as the emphasis on practical skills had been accompanied with increased support from the Department of Basic Education.

...as a physical science[s] educator...I think now they are able to do the practicals and understand them more because everything is given. The manual is there. If the school has the [apparatus], if the teacher does the experiment and the learners also do the experiment then it's a more wonderful thing...

Karabo concurred with Siyanda, adding that the CAPS curriculum was more specific on what abilities and practicals skills to develop in learners and laid out suggestions on how developing these abilities.

Most of the interviewees positively reviewed the Free State Department of Education for their support during the transition from NCS to CAPS. As already highlighted above, many questionnaire respondents (50.6%) rated the departmental support during the transition to CAPS as adequate. Referring to the distribution of textbooks, an issue that had been contentious in other provinces at the time, Karabo said:

...I think they also have to applaud the department for giving us the books in advance allowing educators to go and check the books, making choice of their books because they'll be the ones using those textbooks ...

For Siyanda, departmental support through subject advisors had been sufficient. She elaborated on departmental assistance when she referred to the meetings that are periodically held at cluster level and where important matters concerning physical sciences are discussed with subject advisors and other stakeholders.

For Andres, support from the subject advisors had assisted teachers with content on new topics that had not been available in textbooks. Subject advisors constantly made content available to all physical sciences teachers through a communal online "blackboard", in addition to occasional meetings.

Generally, physical sciences teachers in the Motheo district had positive attitudes and perspectives on the current reform changes. Most of those interviewed stated that the change from NCS to CAPS was long overdue, mostly due to confusion in the NCS, especially concerning practical work and assessment. They are satisfied with the departmental support, especially through subject advisors.

The positives articulated by teachers about current reforms may need to be further reinforced by policymakers to encourage teachers in future, to be more proactive and cooperative towards the implementation process.

While analysis of the positive attitudes and perspectives is helpful, analysis of the aspects that are negative in how teachers are making sense of the reforms is also necessary, for it may possibly respond to the question: what (from teachers' points of view) is not working in the current reforms? Thus, the next frontier after the analysis of those attitudes and perspectives that emerged as positives was to take a closer look at those that registered as negatives in the interviews.

Negative perspectives

Negative attitudes on the part of teachers are forms of obstacles irrespective of whether they are well founded (Lee & Yin, 2010; van Veen & Slegers, 2009). The

open-ended questionnaire revealed some tendencies that could be interpreted as negative. Follow up interviews sought to shed more light on these attitudes and perspectives.

One of the dynamics affecting curriculum implementation is whether educators view reforms as forced upon them in a top-down process (Treu *et al.*, 2010). While widespread official consultations took place before the current reforms, which involved educators through teacher unions and otherwise (UMALUSI, 2014), the teachers interviewed for this study felt differently. On consultations, Siyanda said:

...no consultation was done on my part...I am saying they are making policies for teacher anyway, so the teacher is at the centre of any changes that come; so policy making in an office does not help...

It is important to highlight that this scenario where consultation is reportedly made but the teachers still feel otherwise has been reported as a dynamic in previous curriculum changes (Treu *et al.*, 2010; Graven, 2002). How teachers feel about consultation is still immensely important, irrespective of whether they have been consulted or not. Hence, it is recommended that policymakers do as much as they can to ensure that the agents of the implementation process feel they have been consulted, although of course it must be pointed out that it is not possible to consult every teacher in a way that satisfies everyone else.

Several interviewees cited the 'increased content' as a serious concern. Andres claims that they must resort to doing work outside the designated working hours to make time to complete the syllabus:

...Sometimes I am not able to complete the syllabus, in the moment I am coming in at 05:00 to 07:00 I start with my grade 12s but that I basically use for consolidating chapters, because you don't get time for revision...

This shows a teacher under immense pressure considering that he also works part-time at a local university.

Thus, although UMALUSI (2014) reports that the content in physical sciences has not significantly changed in terms of volume; most teachers expressed feelings of

frustration at what they perceived as an increase in the content, which makes it difficult to complete the syllabus in the available time.

The large amount of syllabus content that needed to be covered was used to explain the time constraints and hence justify why their teaching is not learner-centred, as this would require more time, according to the interviewed participants. The teachers also explained that they organise experimental work in such a way that deals with the problem of lack of time: demonstrations take less time than individual experiments.

The poor quality of the prescribed textbooks generated negative feelings, opinions and perspectives from the interviewed teachers. Concerning the question of whether the existing textbooks meet the current demands of the new topics, Andres responded:

...I am of the opinion you don't really find a good textbook; see I have quite a large source base. Because certain textbooks do very well with this content and others don't do that well in the topic so you must switch between the resources to give the kids the best of everything.

Karabo shared this perspective as he used even stronger terms to criticise the quality of the available textbooks and their inability to address the content requirements of the new topics:

...Largely we don't have good textbooks, there are the new textbooks... and very colourful but when you get into them they are cut and paste...there are lots of corrections to make on those books...

Siyanda echoed these sentiments when she complained that the prescribed textbooks had insufficient exercises and problems for students to practise. She also complained of errors in some of these textbooks:

...The textbook issue is a big issue. Some textbooks do not have a lot of questions. Learners need to exercise through answering questions. They keep on changing textbooks. Study and Masters is very good but has few exercises...such as Olivier has got nice exercises. The three in one was got but they are few of them. So the textbooks are available but you need to choose carefully one that suits your style. Some textbooks have errors in them...

Graven (2002) identified educators' administrative workloads as one of the dynamics affecting curriculum reform implementation while Jansen (1999) singles out the administrative burden on teachers in the C2005 as a serious cause for concern and an obstacle to successful implementation. One of the main reasons for the current reforms was to reduce administrative work on the teachers (DBE, 2014). However, the interviewed physical sciences teachers still felt the administrative work was too much to cope with and in certain instances had possibly increased.

Policymakers sought to reduce the administrative load through the discontinuation of learner portfolios. However, teachers confirmed that little had changed concerning portfolios as Andres explained:

...but to me it still feels as if that hasn't changed, administration is still the same because when the department comes they want the portfolios whereas they said the portfolios are not necessary anymore but you need to have evidence of what was done. So in terms of administration I think it's still a bit of a problem...

Thus, although the authorities meant well in promising to end the demands for portfolios, they did not put a way in place to verify the control work that contributes to School Based Assessment (SBA) as well as evidence for the recommended practical experiments. In the South African educational system, SBA contributes 25% of final grades learners receive, leaving the final examinations to contribute 75%. That left the people who interact directly with the physical sciences teachers (the subject advisors) with no other option but to continue requesting portfolios. In previous curriculum changes, it has been noted that educators often deal with contradictory messages from the authorities (Graven, 2002) and the issue of portfolios is a typical case of this dynamic at play, fourteen years after it first emerged in a South African context.

Although most teachers expressed satisfaction at the level of workshop training for CAPS, they also felt that training for the practical experiments was insufficient.

The interviewees also expressed frustration when they are 'forced' to teach grade 12 learners who failed to meet the promotion requirements to continue into that grade. Although this existed under NCS, it has been exacerbated under CAPS with the increasing emphasis for more learners to do science and mathematics. This has

resulted in learners being “pushed” or being given marks so that they proceed to the next grade. Again, on this issue Andres had the strongest views, saying:

...because there is this euphoria around learners doing sciences... now it leaves the burden on the science teacher... it is policy that as many learners as possible must do science and math...I am saying even none deserving learners are pushed to do science... but let's say we agree that not all learners are science learners anyway, that must be fact, that must be acknowledged....

When the issue of progressed learners came up it was conspicuously charged with emotions. Teachers may feel unfairly treated because of the fear of being called to account when learners fail. The emphasis on results, especially matric results, was evident in the responses and a picture of a workforce under pressure to produce began to emerge. Thandie also shared similar sentiments adding that the pressure is too much, especially for those teaching grade 12 classes. The combined effects of the demand to make every learner pass and of the time constraints have made teachers such as Andres teach outside the normal teaching hours. Physical sciences teachers' frustrations concerning their everyday practice included: lack of training for practical experiments, 'increased content' making it difficult to complete the syllabi, administrative work, progressed learners and pressure to produce good results.

4.7 Physical sciences teachers' practices on the new CAPS

The fifth and sixth questions were framed as below:

Question 5: *How can physical sciences teachers' practices on the new CAPS topics or new subtopics be described?*

Question 6: *How do teachers' concerns and perspectives influence classroom practices on the new topics or new subtopics in physical sciences?*

The responses to these questions could only make proper sense when viewed through the themes that emerged during the observations, interviews and document analysis. Responding to question six entailed explaining how those practices in question five were influenced by teachers concerns (subject of the quantitative phase) and teachers' perspectives (subject of the qualitative phase). Thus, question six required integrating findings from both phases of this study

and it encompasses question five (teachers' practices). I therefore found it more appropriate to respond to questions five and six in a synthetic and integrated approach. However, because part of question six refers to the influence of concerns which were the subject of the quantitative phase I found it necessary to provide a recap of the conclusions of the quantitative phase (cf. section 4.3.4).

While the quantitative phase findings assisted in responding to question two, three and four, they were limited different ways. The results from the initial phase revealed that there were some tasks and activities that most Motheo district physical sciences teachers seemed to have been prioritising over the CAPS curriculum (George, *et al.*, 2013; Hall, *et.*, 1998). However, the results did not reveal what those *tasks and activities* were. These findings could not explain why those *tasks and activities* were of more concern to the physical sciences teachers instead of the CAPS curriculum. Secondly, the results revealed the personal stage of concern as the second highest in relative intensity, indicating that most of the participants were more concerned about rewards and were uncertain about their roles during the CAPS implementation. However, the findings were not specific about what these rewards they expected from CAPS or why they might have been uncertain with regard to their role during this implementation stage. The management Stage of Concern was third highest in intensity, suggesting that a significant number of participants had some concerns about coordination, managing time, managing different tasks (George *et al.*, 2013; Hall *et al.*, 1998). However, these findings did not specify what tasks teachers were having challenges coordinating, or what was causing these time management concerns.

The qualitative data revealed some emerging themes such as insufficient practical skills, insufficient subject content knowledge and pedagogical content knowledge and time constraints. Thus, through interviews and observations, I concluded that the general concerns from the quantitative phase were the same themes that emerged during the qualitative phase but only more specified. Findings from the quantitative phase made sense when integrated with these findings from the qualitative phase. Stages of concern results should not be considered as the final truth but should assist a researcher in formulating assumptions that may be explored through other methods, in this case, observations, document analysis and interviews. In table 4.4 below, I

summarise the relation between the general concerns in the quantitative phase and the themes from the qualitative phase.

Table 4.4: Relation between concerns and emerging themes in this study

Concerns from quantitative phase	Emerging themes from qualitative phase
Personal concerns- uncertainty, rewards and benefits under CAPS	Uncertain about how to teach new topics Insufficient PCK and SCK Insufficient practical skills
Management concerns coordination, managing time, managing different tasks	Time constrains, Managing experimental classes Workloads Large classes in grades 10 and 11
Informational concerns	Notes on new topics below standard Textbooks

The second highest intense stage of concern was the personal, which suggested that teachers were uncertain about their role under CAPS and they were more concerned about rewards and how they benefit from CAPS. The qualitative phase revealed that those uncertainties revolved around some of the teachers being unsure about their SCK and PCK on the new CAPS topics and sub-topics.

The table above does not explain why teachers were unconcerned about CAPS (but rather, they were concerned about other tasks and activities). Further analysis of the emerging themes reveals that these had already been reported as challenges confronting physical sciences teachers even before the inception of CAPS (Basson & Kriek, 2012, Kriek & Grayson, 2009). From the above, I considered it plausible that physical sciences teachers who participated in this study seemed unconcerned about CAPS because they were more concerned about challenges (emerging themes) that were already existent even before CAPS. To these teachers, these were not identified as CAPS problems because they already existed before the inception of CAPS. Thus, I established how concerns from the quantitative phase emerged as themes during the

qualitative phase. Furthermore, I identified these themes as challenges teachers were confronting during the implementation of CAPS. Below, I discuss how physical sciences teachers' concerns (specified emerging themes) and perspectives influenced teachers' practices especially on the new topics and subtopics. In the process, teachers' practices are described in response to question five.

4.7.1 Physical sciences teachers' perspectives, insufficient practical skills and their influence on classroom practices

A lack of sufficient practical skills among science teachers has been identified as one of the key reasons for poor science learning (Mizzi 2013; Barnea *et al.*, 2010). In times of curriculum changes, such a lack of sufficient experimental skills is magnified whenever new experimental requirements are added, as in the introduction of CAPS in South Africa. Indeed, some of the most significant changes in physical sciences are to the recommended practical experiments in chemistry and physics (UMALUSI, 2014).

Thandie, the chemistry graduate who taught seventy kilometres out of Bloemfontein was more specific and elaborate. She explained how new practical requirements impacted her as a physical sciences teacher who is only majored in chemistry yet is also expected to assist learners in chemistry and physics practicals. For Thandie, it took less time and less effort to prepare a chemistry practical than it would take to prepare a physics practical.

One way teachers have adopted to cope with these challenges is to use available assistance from other stakeholders. Document analysis revealed experimental worksheets detailing hypothesis formulation, procedures and post experiment questions that would form the laboratory report learners would submit. There were two main sources of these worksheets namely, the subject advisors and University of the Free State Schools Partnership Project. Each of the five teachers who participated in observations, interviews and document analysis had these materials from either of these two sources or both. None of these teachers was preparing their own worksheets: they were simply making copies of particular worksheets from the materials they had. Most of these worksheets were however, well designed (See Appendices J and M).

The observed practical experiments revealed a general pattern: learners are issued with a worksheet with laboratory procedures; they are grouped (mostly for grades 10 and 11) and follow simple procedures, record the results and answer a few questions to complete a laboratory report. These procedures indicate a state of affairs that is far from achieving "...inquiry-oriented laboratories that have the potential to enhance learners' meaningful learning, conceptual understanding, higher order thinking skills, and understanding of the nature of science" (Barnea *et al.*, 2010: 218). To achieve the above "inquiry-oriented laboratories", learners would have to be engaged in hypotheses formulation, solving scientific problems, designing experiments, gathering and analysing data and drawing conclusions about scientific phenomena. They would also need to ask research questions, reflect on their findings, clarify understandings and misunderstandings with peers and base their conclusions on a range of resources (Barnea *et al.*, 2010; Hofstein & Walberg, 1995; Tobin, 1990; Krajcik, Mamlok & Hug, 2001). While the physical sciences teachers' practices that were observed indicate some aspects from this long checklist, they still fall short.

4.7.2 Physical sciences teachers' perspectives, time constraints and their influence on classroom practices

Time constraints, as a dynamic affecting teacher implementation of curriculum reform, is probably the most complex due to its relationship with other factors such as workload, deficiencies in SCK and PCK regarding new content, practical laboratory skills or even the quality textbooks.

All the interviewed teachers except Karabo cited time constraints as a serious concern in their implementation of CAPS. The first reason that there are time constraints, according to the teachers, is due to the increased content that needs to be covered under CAPS. Time constraints were used to justify continuing with a teacher-centred approach alongside the widespread use of practical demonstrations instead of individual inquiry-based approaches. Siyanda mentioned that she was not able to carry out some of the experiments with her learners. When asked why, she responded as follows:

...Usually it's time...there are time constraints, you cannot do that...So you can only do the demonstration and sometimes you can only give learners some worksheet on the experiment to practise and then they will have the answer...

Siyanda also blamed administrative demands as adding to the time constraints. She adds:

We are always being interrupted by the administration. That's my main problem that I have with CAPS... to me it still feels as if that hasn't changed, administration is still the same and it takes a lot of my time because when the department comes they want the portfolios whereas they said the portfolios are not necessary anymore but you need to have evidence of what was done...

On being asked why he was mostly using demonstrations instead of individual experiments, Andres added:

...So there is no time, that's one thing...there is no time to do these things...it doesn't help us giving learners, because any learner-centred activity needs time...

Thabo viewed time constraints as having a significant impact on his classroom practice. On being questioned why he focuses on group experiments rather than individual experiments he echoed the sentiments expressed by the others:

Do you know what; time is a big issue because I mean like how long will it take you if you have forty-five learners in a class and each one has to do that practical, you must set it up, prepare before and you must still assist them while they are busy so that they don't copy so that is also a bit of a challenge if they have to do that individually now...

Andres is convinced that a learner-centred approach is best but he also thinks there is little time to do that and that is why most of his teaching is teacher-centred. He added:

...because sometimes you are told let's say to become learner-centred but things like time also influence because the moment you see that time is limited then coaching takes a lot [of] time then you push that aside then you start teaching...

To cope with their perceived time constraints most of the interviews teachers had resorted to teaching outside the normal working hours. Andres reported that he taught very early in the morning before seven o'clock, while every one of the interviewed teachers said they taught on most Saturdays especially the grade 12 classes.

Another way of coping with these perceived times constraints involved adopting a teacher centred approach during the teaching and learning process. Learners are given little time to ask questions and the process is often reduced to the teacher scribbling notes on the board as learners copy them into their notebooks.

The perceived time constraints could also partly explain why the use of group experiments and demonstrations was widespread especially in grade 10 and 11. However, such practices in the laboratories could also be due to badly equipped laboratories or lack of resources. Learners did not complete the experimental activities for most of the practical lessons I observed. The laboratories involved, in most cases, learners following predetermined procedures as opposed to enquiry approaches. This seemed to be a way of either coping with the time constraints or with the lack of skills to conduct inquiry laboratory practices on the part of the teachers or a bit of both time of constraints or insufficient skills.

From these interviews, I could also picture scenarios where valuable time is also consumed as teachers try to collaborate with each other to mitigate their deficiencies in experimental work or in content related matters. Sometimes sifting through different inadequate textbooks could also take much of their time. Thandie confessed that it required more time to prepare physics experiments when compared to chemistry experiments as she was majored in chemistry.

There were also genuine concerns from these teachers that physical sciences, as a composite of two subjects both with practical components, requires more time than other subjects. Comparison of content across subjects is a challenging endeavour.

Whether it is because teachers are using valuable time to work out what to do or whether the content is fundamentally too much to cover in the time available is not

easy to determine. What is certain is that the issue of time was a factor that teachers reported as having an adverse effect on the quality of CAPS implementation. While the UMALUSI (2014) concludes that the content in physical sciences has not significantly changed between CAPS and NCS, there is a possibility that the physical sciences teachers and UMALUSI (2014) are confirming that the content has not changed significantly but there was already too much content under NCS. Many studies on the challenges and contentious nature of the depth versus breadth dichotomy have been carried out (Schwartz, Sadler, Sonnert & Tai, 2008; Shubert, 1986). These studies often pit those scholars advocating for more breadth than depth against those advocating for greater depth than breadth (Hirsch, 2001; Newmann, 1988; Schmidt, Hsing & McKnight, 2005).

Time constraints are a complex phenomenon. Insufficient SCK and PCK, large classes, lack of sufficient practical skills, large administration workloads, large content or complex content may all lead to challenges that can manifest as time constraints. I could only conclude that whenever time constraints are reported, it is usually not one factor involved but a complex of interrelated factors that are impeding the smooth flow of curriculum implementation. More research needs to be done on this complex aspect of time constraints during the present and future curriculum changes.

4.7.3 Motheo district physical sciences teachers' perspectives, knowledge about CAPS, SCK and PCK and their influence on practice

Physical sciences teachers' knowledge emerged as a theme with three categories, namely, general knowledge about the CAPS changes, SCK and PCK. In this section I describe how some of the physical sciences teachers' concerns and perspectives in regards to CAPS were influencing their practices.

During the interviews, teachers could easily articulate when confronted with the question relating to what the new topics (or sub-topics) were under CAPS. Andres said:

...some new content was introduced if I quickly think of something like acids and bases was not done so much in detail in grade 12 anymore and now they suddenly re-introduced it...

Most participants mentioned and elaborated on the acid and bases topic and this is important as I consider this change to be the most significant in physical sciences in terms of content additions. There is a whole question based on the topic in the matric final examination, with between 15 and 20 marks out of the 150 available for chemistry. Arguably, the most emphasised experiments are titrations, based on the acid and bases topic, cementing the importance of the topic towards overall results. Regarding titration experiments, Karabo said:

...Yes, remember on first year level university you also have to do those titrations and if you can't even mix those thing together then you stay the classroom for about a week not being able to titrate.

In Karabo's case, not only does he understand the topic, he also understands and appreciates their importance of it regarding his learners. Such a teacher is most likely to be more motivated towards bridging the gap between what they know and what they do not know about the new topics. When I directed the interview towards the practical emphasis under CAPS, Karabo quickly pointed out that there are 12 practical abilities articulated under CAPS.

Despite teachers' clear articulation of new content knowledge; many seemed confused when the interview was directed towards subjects such as learner-centeredness, teacher-centeredness or constructivism. When I asked Thandie if her teaching had become more learner-centred or more teacher-centred she seemed confused:

...Learner-centred? I don't know... what is that?

When I clarified to her what learner-centred and teacher-centred meant, she further responded:

...To me it's still the same, I don't know. NCS we were doing the same thing..."

It is probably only natural to sympathise with teachers such as Thandie, as the CAPS curriculum does not say anything regarding the teacher's role and educators seem to have been reduced to being implementers of a predetermined learning programme (UMALUSI, 2014). On the other hand, the inability to differentiate between learner-centeredness and teacher-centeredness for a science teacher such as Thandie could be due to deep-seated issues about educational qualifications and training. Thandie

had an honours degree in pure chemistry but has no background in education theory or in the theory of teaching and learning. Neither did she have any qualification to teach physics.

Except for Thandie, all the other teachers who were interviewed explained and articulated the changes in the practical experiments very well. However, whenever the interviews were directed towards the theoretical underpinnings of education, such as inquiry-based experimental approaches, teachers seemed to find time as a good excuse. Teachers could explain clearly when asked for the reasons why NCS was 'repackaged' into CAPS, citing the need for clarity on what to teach and reducing the amount of administrative duties on teachers; at the same time, they also claimed not to have experienced the reduction in administration, with some even claiming it had increased.

Since physical sciences teachers' classroom practices are largely dependent on their knowledge, they will need to learn novel pedagogical methods and new content to be able to enact curriculum reform (Wallace & Loudon, 1998; Borko & Putnam, 1996; Schneider *et al.*, 2000).

The changes from NCS to CAPS are characterised by new sub-topics in chemistry and physics and these are a challenge to most teachers despite the assistance from subject advisors as indicated by some of the interviewed teachers. While "good notes" may be made available to them from different sources (such as the University of the Free State Schools Partnership Project or subject advisors) physical sciences teachers need to have dominion of this knowledge. A lack of dominion of SCK often results in teachers presenting the content to learners as predetermined, "socially sterile, impersonal, frustrating, intellectually boring..." (Aikenhead, 2007: 886). Physical sciences notes, however 'well prepared' they might be, do not magically make anybody a good physical sciences teacher. When equipped with good notes or a good textbook, teachers still need to transform these into live examples of the process of science, which entails having a developed pedagogical content knowledge.

An example is Thandie's presentation of emission and absorption spectra, which she summarises by writing the definitions for her learners to copy. The possible multiple representation of this material, the history of the development of this knowledge and

its applications, were all missing from her presentation. She missed opportunities to refer to significant scientific developments that took place at the beginning of the twentieth century involving some of the greatest science progenitors since Isaac Newton, such as Max Plank, Albert Einstein and Niels Bohr. Thandie did not need to spend twenty minutes on the history of science but when opportunities arise, she could briefly but usefully refer to the social context in which science evolved. Seeing this opportunity pass by in Thandie's class, I wondered if she knew about the social context in the development of emission and absorption spectra and quantum physics. I also wondered if it occurred to her that this social context and the participation of these progenitors in this shared endeavour could be one of the reasons curriculum developers included this topic in the syllabus.

Shulman (1987: 8) has described PCK as "...special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding". PCK is the synthesis of all knowledge needed to be an effective teacher (Shulman, 1987).

Andres' class emphasised the value of PCK in the same sense as Thandie's, only in a different context. The concept of dissociation he was teaching is especially difficult for learners as it involves invisible and abstract entities and processes, while learners' thinking heavily depends on sensory data (Ben-Zvi, Eylon & Silberstein, 1987; Griffiths & Preston, 1992). Chemical knowledge is learned at three levels or representation: macroscopic, symbolic and sub-microscopic, and the link between these levels should be explicitly taught (Ebenezer, 2001; Ravialo, 2001; Treagust *et al.*, 2003). While he used macroscopic representations (learners having first hand interactions with real acids and bases) and symbolic representations (use of equations) he failed to use microscopic representations and to link how these three representations could assist in completing the formation of the concept of dissociation. There was little doubt that Andres understood the concept of dissociation but from my observations, as he taught, it was not evident that he possessed the "...synthesis of all knowledge needed to be an effective teacher..." of acid-base scientific models (Shulman, 1987:8).

The evidence of a lack of PCK in the participants of this study is not limited to the two examples cited above. On interviewing the teachers, one does not hear about PCK,

rather their emphasis is about content knowledge. Is it plausible that most physical sciences teachers (in this study and in general) cannot distinguish between the different knowledge domains? Further research may assist in shedding light on teachers' knowledge domains.

Karabo, who only majored in chemistry, points out that it would greatly assist teachers such as himself if there were more workshops on the new content when he says:

...It's also going back to saying we are not perfect all of us, if we can be able to bring on those teachers' development regularly ... it's not going to help us.... Teacher development means that it has to be content...especially in the new topics...

Upon further probing Karabo on what topics he thought he needed assistance with, he mentioned the big bang, acids and bases, polymers, Newton's laws, emission spectra and the Doppler effect. What becomes more interesting is that although he mentioned new topics in chemistry, he also mentioned physics topics previously included under NCS, raising the possibility that he might have been struggling with teaching those topics before CAPS, having only majored in chemistry.

Thandie, the teacher who was majored in chemistry with no qualification in education but was teaching chemistry and physics topics, said:

...I'll say especially in certain topics it really assists you, in certain topics just that you know the time is a bit limited you feel if the workshop would have been longer it would have been better but you also understand the time is a big factor... Yah, especially the new topics that they have brought into CAPS they assist you a lot...

When I probed Thandie further on what topics she would like assistance with through organised workshops, he said:

...Photoelectric effect is new,.. even work energy theorem and Big Bang; the way they ask questions. The content were there, the way they ask the questions is a bit challenging...

The topics or subtopics that Thandie confessed she was struggling teaching happened to be mostly physics topics. This was not surprising considering her academic

background. Though the topics on photoelectric effect or work energy theorem are, in fact, not new, Thandie also articulates a problem related to subject content that current teachers might be facing: the way questions are being asked in the examinations has changed to demand more and higher level cognitive skills from the learner. NCS questions tended to provide a hint as to how learners should respond.

Andres, Thandie and Karabo, who were all majored in chemistry, admitted that for them, teaching physics topics was not as easy as teaching chemistry. They were uncertain with regards to how best to teach the new physics topics.

Besides the observations made in this study, the interviews confirmed insufficient subject content knowledge (SCK) and pedagogical content knowledge (PCK) in the Motheo district. However, it would be untrue to state that this observation is solely due to the new sub-topics introduced in CAPS. Insufficient SCK and PCK already existed among some of the physical sciences teachers before CAPS (Basson & Kriek, 2012; Mokiwa, 2014). This insufficiency in knowledge domains is magnified during curriculum reform. The challenges reach critical proportions when teachers have not majored in both subjects of physical sciences.

Motheo district physical sciences teachers had devised ways to cope with these insufficiencies in SCK and PCK. Teacher centred approaches, which were assisting them in coping with their reported time constraints, were also ways to cope with insufficient SCK and PCK. When teachers are uncertain about SCK they tend to be authoritarian and reduce discussions and questioning from learners (Cohen, 1999; Ramnarain & Fortus, 2013). Teachers also depended on notes, worksheets and laboratory report templates provided by subject advisors and other stakeholders such as the University of the Free State Schools Partnership Programme and Jenn Education consultancy. These support materials were used in conjunction with the CAPS assessment Guidelines, the Examinable Content Booklet, the work schedule and past examination question papers.

The majority of Motheo district physical sciences teachers need to have a deeper understanding of content; they need to relate it better to other parts of the curriculum and embed contexts in which some of the scientific discoveries took place if they are to transform and develop these into their own PCK. Motheo district physical sciences

teachers had developed strategies to cope with their insufficiencies. While these approaches may be effective in preparing learners to be successful in examinations, it is not clear whether they would achieve the specified subject objectives such as promoting knowledge and scientific inquiry and problem solving.

4.8 Integration and synthesis of results from the study

While there has been research on curriculum implementation in South Africa in recent times (Basson & Kriek, 2012; Nakedi, 2014; Moodley, 2013; Ramnarain & Fortus, 2013), the literature lacks studies exploring teachers' concerns, even though teachers are the central agents of change. While using the concerns-based adoption model (CBAM) and mixed methods to explore teachers' concerns during reforms is widespread on the international research platform (Al-Shabatat, 2014; Penuel *et al.*, 2014; Becker, 2011; Cruz, 2014; George, 2015; Jennings, 2015; Nawastheen *et al.*, 2014; Puteh *et al.*, 2011), this approach has been conspicuously absent among South African implementation researchers. This study enriches the local research terrain with a robust combination of CBAM, stages of concern questionnaire and mixed methods as approaches that can be used to unpack the complexities of curriculum implementation in South Africa.

The participants for this study had generally higher academic qualifications than those in a related study to evaluate the readiness of physical sciences teachers to implement CAPS (Basson & Kriek, 2012) where 80% of the teachers did not possess a teaching qualification in physics, chemistry or physical sciences. What has often been lacking in previous studies on physical sciences during times of curriculum reform is unpacking the challenges related to physical sciences as a composite of two subjects and the struggles that emerge because of teachers' qualifications (or lack thereof) and readiness or unpreparedness to meet the cognitive demands of teaching chemistry and physics topics.

The stages of concern indicated that most of the physical sciences teachers who participated in this study were at the unconcerned stage of concern. The highest peak was found at the unconcerned with a second and third peak at personal and management respectively. Having the highest score on the unconcerned stage and

second highest peak at the personal stage indicates that most the Motheo district physical sciences teachers who participated in this study appeared to be more concerned about self-concerns, status rewards and the manner in which CAPS influenced them. Questions such as “how does CAPS make my work easier?” could be at the back of teachers’ minds. It also suggests that the teachers might be uncertain about the demands of CAPS, how these demands differ from the previous NCS and their role in the implementation process (Hall & Hord, 2011; George *et al.*, 2013; Hall & George, 2013).

The observations and interviews revealed familiar challenges to physical sciences teachers in the Motheo district: insufficient knowledge domains, time constraints, insufficient laboratory skills, heavy workload and contradictory messaging from the authorities. These matters have been cited in recent literature as challenges facing teachers in South African schools in general and some particularly in physical sciences (Basson & Kriek, 2012; Nakedi, 2014; Moodley, 2013; Treu *et al.*, 2010). Most of the concerns and challenges that physical sciences teachers experienced under NCS still exist and some have even been magnified by the introduction of new sub-topics and the increased emphasis on practical hands-on experiments that learners need to experience. Hence, these teachers are “unconcerned” about CAPS. This does not necessarily mean they do not care about CAPS; it simply means the concerns they had under NCS are still exerting an overriding influence on them, surpassing other forms of concern about CAPS.

The above aligns well with teachers’ initial perspectives on whether they thought it necessary to change the curriculum from NCS to CAPS. There was consensus that there was a need for the change, as cited in their responses (section 4.5.4, above). When one integrates the initial results from the stages of concern and the consensus perspective for change, one begins to see that the physical sciences teachers envisaged that the change from NCS to CAPS would address the challenges mentioned above. Results from the observations and interviews indicate that this has not occurred, at least not in the way that aligns with most expectations of the participants in this study.

The unconcerned stage of concern often means that the teachers' concerns are unlikely to shift from the lower concerns (an indicator of challenges in the implementation of a reform) to higher stages of concern (an indication of successful implementation). This shift would only be possible when those concerns (personal concerns in this case) are addressed. For most participants, the shift to higher concerns would only be possible when they perceive that their concerns about workloads, time constraints, deficiencies in SCK, PCK and practical skills have been addressed.

The MANOVA results testing the hypotheses also align with the above. There were no significant differences due to years of experience or academic qualifications in the stages of concern raw scores. It appears that existing factors levelled the field for most participants, irrespective of academic qualifications or years of experience and most of them were grappling with the same challenges as under NCS. Until these are addressed, most teachers would be "stuck" in the lower stages of concern. Becker (2011), in a doctoral study, concluded that when teachers' personal and managerial concerns are not identified or addressed by those responsible for supervising the implementation, they tend to become disinterested in using the implementation. For most of the physical sciences teachers who participated in this study, the initial excitement that CAPS would resolve some of the challenges experienced under NCS had been replaced by attitudes of indifference towards CAPS. Indifference could be the other term for 'unconcerned'. Most teachers responded by making slight adjustments to enable themselves to cope with the new topics and subtopics and with the new practical requirements. However, these adjustments have not necessarily improved the teaching and learning process in alignment with current research findings.

Challenges faced by physical sciences teachers in effectively organising laboratory activities are well documented (Mizzi, 2013; Barnea, 2011) and these can only be magnified in times of curriculum reform, especially for teachers who only majored in one subject but are expected to assist learners in the laboratory in chemistry and physics experiments. This study goes beyond classifying physical sciences teachers simply as degree holders or diploma holders by breaking down the numbers of those who have chemistry or physics qualifications, both or none. The composite nature of

physical sciences was explored and its implications discussed, such as contributing to teachers' challenges especially those who teach chemistry and physics topics when they are only qualified to teach one of the two. What compounded this challenge in the Motheo district was that most of the physical sciences teachers (92.6%) were teaching chemistry and physics topics when the study was conducted.

The study sheds light, not only on the challenges faced by most physical sciences teachers in the current implementation but also on how these are linked to the previous NCS. Although the dynamics affecting implementation of the new reforms have been previously discussed (Basson & Kriek, 2012; Nakedi, 2014; Moodley, 2013; Treu *et al.*, 2010), this study sheds more light on how unaddressed dynamics from the previous curriculum can negatively affect the implementation of the next curriculum. Furthermore, the results provide avenues for policymakers to acknowledge and identify physical sciences teachers' concerns during the current CAPS reform implementation. These avenues may ease the formulation of strategies aimed at enhancing the present and future implementation process.

Generally, the physical sciences teachers who participated in the interviews were receptive to CAPS, as indicated by their positive affective domains, coinciding with the findings of Ramnarain and Fortus (2013). Most teachers stated that there was a real need to introduce CAPS. However, their negative affective domains might have stemmed from disappointments and frustrations that CAPS had failed to live up to expectations in dealing with the challenges they had already been struggling with under NCS and even under C2005. Teachers have their own priorities and personal concerns in times of curriculum change and these priorities are at times related to challenges experienced with the outgoing curriculum. When the new curriculum fails to address these challenges, teachers may become indifferent to the new curriculum and this may be mistaken for resistance to change. Teachers' prior perspectives and practices (on NCS) can pose challenges not only because teachers are unwilling to adapt to new policies (CAPS policies), but also because their existing subjective knowledge may interfere with their ability to interpret and implement new reform in ways consistent with policymakers' intent (Spillane, 2006).

Most of the Motheo district physical sciences teachers who participated in this study were experiencing some of the challenges that have been reported in previous times of curriculum reforms in South Africa: insufficient SCK, PCK, time constraints and lack of inadequate laboratory practical skills (Basson & Kriek, 2012; Nakedi, 2014; Moodley, 2013). This coincides with Ramnarain and Fortus (2013) in their study on South African physical sciences teachers' perceptions of new content in a revised curriculum. However, the present study goes further than Ramnarain and Fortus (2013) in that through direct classroom observations, it gives vivid pictures of learner-teacher interactions, thereby revealing the type of SCK and PCK that teachers might have been struggling to incorporate into their practices. Some of the PCK issues identified are the use of multiple representations in chemistry topics, especially microscopic representations and the history of science in physics.

The time constraints and pressure experienced by teachers during times of reform are among the most complex aspects to analyse. In this study, time constraints are used to justify using a teacher-centred approach over a constructivist inquiry-based approach. Time is also used to justify the use of demonstrations instead of experimental settings where learners get an individual hands-on experience of science in a laboratory. Most participants in this study blamed the lack of time on large amounts of content and this may be well-founded, despite reports concluding there has been no change in size of the content between CAPS and NCS (UMALUSI, 2014). It is plausible that the content was already too much even before CAPS as time constraints have been reported during NCS (Treu, 2010). While teachers' time related concerns may be well founded, this study concludes that some teachers may have to use valuable time trying to work out what to do, especially concerning practical experiments. When teachers are dependent on subject advisors to update them on the content on the new topics, it takes yet more time to attend workshops. The need to use several textbooks (as many as seven textbooks have been reported as being used, none of them being adequate for CAPS), also means that teachers spend time sifting through different texts, trying to locate helpful content.

To cope with the challenges, participants in this study had devised strategies, including using support materials from subject advisors and other stakeholders, using class

demonstrations instead of individual experiments, and increased teacher-centred approaches in their practices. Despite these coping mechanisms, this study concludes that the current reforms might not have significantly changed teachers' practices.

Despite physical sciences coping mechanisms cited above, this study concludes that the current reform efforts from NCS to CAPS might not have significantly changed teachers' classroom practices, as inferred from their concerns and perspectives. What may have changed are policymakers' approaches and expectations towards teachers' practice. They have shifted their emphasis to change teachers' practices towards a constructivist, learner-centred approach and seem to conform to a teacher-centred, traditional, content driven, examination oriented approach. While the support materials at the micro-level of the curriculum from other subject advisors and other stakeholders were providing relief to teachers, this approach should not be regarded as a long term solution. In the next chapter I offer recommendations that may enhance CAPS implementation and suggest directions for future curriculum changes in the physical sciences.

4.9 Chapter four summary

In this chapter, I discussed and analysed the findings of this study. The starting points were results from the stages of concern questionnaire, which helped to formulate questions. The analysis of the observations and interviews then helped to address these questions. The integration of the stages of concern questionnaire results with other findings from questionnaire, observations and interviews assisted in holistically capturing the state of CAPS implementation by physical sciences teachers in the Motheo district of the Free State. In the next chapter, I conclude the study by summarising the findings from this chapter and in particular, how they relate to the literature review. Knowledge gaps and areas for future research are discussed and a brief overview of the limitations of this study will be given.

Chapter five: Discussion of findings and conclusions

5.1 Introduction

In this final chapter, a summary of the research is provided along with the key findings and the significance of the study. Lastly, conclusions and recommendations are discussed.

The literature is replete with studies that employ a combination of the CBAM instruments and mixed methods to investigate curriculum implementation in some parts of the world (Becker, 2011; Puteh *et al.*, 2011; Nawastheen *et al.*, 2014; Çetinkaya, 2012; Al-Shabatat, 2014). Despite the contentious nature of recent curriculum reforms and their implementation in post-apartheid South Africa, the use of this robust combination of instruments and methods in exploring physical sciences teachers' perspectives and practices during times of reforms and the dynamics of these, is quite scarce. Thus, using the mixed methods and CBAM stages of concern questionnaire in this study puts at the disposal of future researchers more alternative methods and instruments to curriculum research implementation in the South African context. The results of this research study have been discussed and interpreted in the context of the broad literature review presented in chapter two.

5.2 Overall summary of the research

During times of curriculum reform, there is usually an implementation gap existent between what policymakers have in mind about any reform and the way teachers interpret and implement the reform (Brown & Campione, 1996; Brown & Edelson, 2001; Cordray & Pion, 2006; Creswell, 2013; Cuban, 1998; Fullan, 1993; Lopez & Wise, 2015; Sarason, 1990; Spillane, 1999). This implementation gap can be narrowed through understanding how teachers, the central agents of the change process, are making sense of the current reforms. Recent curriculum reform efforts in the South African education system have failed at the implementation stages. This study explored physical sciences teachers' perspectives and practices during CAPS implementation in the Motheo district of the Free State in South Africa. The study also explored and determined the types of relationships, existent between these concerns and demographic aspects such as years of experience or level of educational qualification. The CBAM instrument used to explore these concerns, the stages of concern questionnaire, is based on the following assumptions: firstly, curriculum

implementation is a process. Secondly, change is individual. Thirdly, the perceptions and feelings of individuals are critical for successful reform. Fourthly, individuals go through different stages regarding how they feel about reforms as well as their capacity and ability to align their practice with those reforms. The broad argument of CBAM is that if those in charge of policy reforms are to assist the on-site agents of implementation, in this case physical sciences teachers, then they have to be aware of the concerns that teachers harbour (George *et al.*, 2013).

The main research question for this study is: *What are the physical sciences teachers' perspectives and practices on CAPS during this early implementation period in South Africa?*

Table 5.1 below, displays the sub-research questions and the corresponding instruments used to respond to them.

Table 5.1: Sub-research questions and the corresponding instruments

Research question	Research instrument
1. What perspectives do physical sciences teachers have regarding the changes in the CAPS?	Interviews
	Open-ended questionnaire
2. What are the common concerns that practising physical sciences teachers have about the implementation of the new CAPS curriculum?	Stages of concern questionnaire
	Class observations
3. What relationships exist between physical sciences teachers' concerns about the CAPS curriculum and their level of education?	Stages of concern questionnaire
4. What relationships exist between teachers' stages of concern and their number of years of experience?	Demographic data questionnaire
5. How can physical sciences teachers' practices on some of the new CAPS topics or sub-topics be described?	Lesson observations
	Interviews
	Document analysis
6. How do physical sciences teachers' concerns and perspectives explain some of their classroom practices on the new CAPS topics or sub-topics?	Stages of concern questionnaire
	Lesson observations
	Interviews
	Document analysis

To respond to question one in full required the use of interviews and an open-ended questionnaire. A satisfactory response could only be achieved by firstly interpreting the data from the stages of concern questionnaire followed by observations of some teachers' classroom practices and semi-structured interviews. The relationship between teachers' concerns and their qualifications (question number three) could only be explored by integrating results from the questionnaires and the demographic data. Lesson observations, interviews and document analysis were used to characterise physical sciences teachers' classroom practice. The stages of concern questionnaire and the interviews were used to respond to question number five. The complex nature of question six required the integration of findings from the stages of concern questionnaire, interviews, document analysis and lesson observations to shed light on how teachers' concerns and perspectives influenced their classroom practice.

Hence, to respond to all the above questions, this study employed a sequential explanatory mixed methods approach. The quantitative stage involved using the stages of concern questionnaire conducted on 81 participants in February 2016. SPSS was used to construct individual and group peak profiles and one-way between-group multivariate analysis of variance (MANOVA) was conducted to investigate the relationship between demographic variables such as years of teaching experience and SoCQ raw score means. In addition, while robust, the stages of concern questionnaire was a source of assumptions that were further explored during the subsequent qualitative phase. Classroom observations to explore the teaching practices and interviews were conducted on five (5) participants from the initial 81 teachers who participated in the stages of concern questionnaire. The selection of participants for the observations and interviews was based on peak profiles and demographic data. I sought a sub-sample representative of the sample in terms of background, teaching experiences, qualifications and gender.

5.3 Key findings and their significance

Curriculum implementation is known as quite a complex and difficult process (Holloway, 2003; Spillane *et al.*, 2002), and often the proposed curriculum innovations do not produce the desired results (Christou *et al.*, 2004; Spillane *et al.*, 2002). While there have been some studies on the general implementation of CAPS, little is currently

known about physical sciences teachers' concerns, perspectives, practices and understanding of the changes and the transition from NCS to CAPS. Despite a series of education reforms since 1994, which have all had problems during the implementation stages, research focusing on the teachers, who are agents of change during the process, is still scarce. Yet the literature is replete with confirmations that education reforms, however well intentioned and developed they might be, are most likely to fail during the implementation stage if teachers' concerns and perspectives are not considered (Spillane *et al.*, 2002). Therefore, this study explored physical sciences teachers' concerns and perspectives regarding CAPS. A better understanding of physical sciences teachers' concerns and perspectives will assist policymakers in formulating strategies that remove barriers to change existent in the current system and ultimately reduce the "implementation gap".

The implications and significance of the results of this study will be discussed in alignment with each of the following research objectives:

- a. Determining physical sciences teachers' attitudes and perspectives regarding the new CAPS.
- b. Highlighting the Motheo district physical sciences teachers' concerns during the implementation of CAPS.
- c. Determining the relationship between academic qualifications and their stages of concern.
- d. Determining the relationship between teachers' experience and their stages of concern.
- e. Describing physical sciences teachers' practices on the new CAPS topics or sub-topics.
- f. Explain the influence of physical sciences teachers' concerns and perspectives on their classroom practices on the new CAPS topics or sub-topics.

5.3.1 Motheo district physical science teachers' perspectives on CAPS changes

To explore the Motheo district physical sciences teachers' perspectives on CAPS, question one below, was examined.

What perspectives do the Motheo district physical sciences teachers have about the changes in CAPS?

The study found significant patterns perspectives that may be pivotal in the way physical sciences teachers were implementing CAPS in the Motheo district. Generally, the physical sciences teachers who participated in the interviews were receptive of CAPS. Most of them stated that there was a real need to introduce CAPS. This coincided with previous findings (Ramatlapana & Makonye 2013; Ramnarain & Fortus 2013).

However, the most significant difference between my study and others resides in the depth of the exploration of the perspectives. Further analysis of these perspectives, especially regarding their reception of CAPS revealed that possibly the most important question about teachers' perspectives is *to which aspects of CAPS are teachers most receptive?* Are teachers positively receptive because they expect an innovation to resolve certain issues they have been struggling with (innovation expectations) or are they receptive because they have already experienced and witnessed the advantages of the innovation (innovation experiences)?

When the new curriculum fails to address challenges or concerns, teachers' perspectives may become indifferent to the new curriculum and this could be mistaken for resistance to change. Becker (2011) concluded that when those responsible for supervising the implementation do not identify or address teachers' personal and managerial concerns, they tend to become disinterested in using the implementation.

In this study, I theorise that when teachers are receptive of the innovation because of their experience with the innovation, especially when they are about how the innovation has positively influenced them on a personal level and in terms of management of their daily tasks, teachers are more likely to cooperate for successful implementation. When teachers' receptive perspectives are based solely on "innovation expectations" and the innovation does not meet those expectations, teachers may become indifferent towards the innovation and may "remain stuck" in the old ways of practice. This may result in the innovation failing to achieve the aim and objectives the policymakers had in mind.

In this study, physical sciences teachers' negative perspectives might have stemmed from some disappointments and frustrations that CAPS had failed to live up to their expectations in dealing with those challenges they had already been struggling with under NCS and even under C2005. Teachers have their own priorities in times of curriculum changes and these priorities are at times related to challenges experienced with the outgoing curriculum. New curricula could be better implemented when they address teachers' personal and managerial concerns, which they experienced in the previous curriculum.

5.3.2 Motheo district physical sciences teachers' common concerns on CAPS implementation

The second question for this study read:

What are the common concerns that practising physical sciences teachers have about the implementation of the new CAPS curriculum?

In the quest for a response to this question, the stages of concern questionnaire was used. The findings served as tentative hypotheses, which were further explored through interviews and an open-ended questionnaire.

The questionnaire results and their analysis suggest that physical sciences teachers in Motheo district are at the unconcerned stage, with second and third peaks pointing to personal concerns and concerns regarding management, respectively. A holistic interpretation of these results indicated that most of the participating teachers were firstly, concerned about their uncertainty to meet CAPS demands and were not certain about their role in the implementation of CAPS (George *et al.*, 2013). This confirms that "...where NCS clearly articulates the teacher's role, CAPS does not refer to the teacher's role" (UMALUSI, 2014: 15). Secondly, issues related to using resources, information, efficiency, organising, managing and scheduling were also dominant among the teachers. While previous implementation research had identified some of these as general dynamics affecting reform implementation (Treu *et al.*, 2010), this study goes further specifying them as pertaining to a specific subject area (physical sciences).

While the stages of concern revealed these concerns in a general way such as information or coordination of tasks, observations and interviews assisted in specifying

them. Most interviewees decried the time constraints that have worsened under CAPS, largely due to the practicals that they and learners are now required to do and for which they have to provide show evidence. These feelings corresponded with responses about workloads, with 86% saying their workloads have increased due to the change from NCS to CAPS. This would be a setback for policymakers, who had proclaimed that one of the aims of CAPS was to reduce the amount of paperwork that teachers handle. Teachers were also concerned that subject advisors still demanded learner portfolios documenting all formal activities throughout the year, despite initial assurances that the system was going to discontinue the inspection of portfolios. This kind of inconsistent messaging, as one of the dynamics hindering any implementation, is well-documented (Treu *et al.*, 2010) and could have been avoided.

Analysis of teachers' concerns revealed that most of the Motheo district physical sciences teachers were more preoccupied by concerns they had grappled with under NCS and the resolution of these had remained as a priority for them overriding any other concerns CAPS might have ushered in.

5.3.3 To determine the relationship between teachers' stages of concerns and teaching experience and academic qualifications

To comprehend teachers' changing or developing stages of concern during times of curriculum reforms, it is important to explore how other factors affect this development. Intervention strategies could be developed in ways that account for the impacting factors. The relationship between teachers' stages of concern, their teaching experience and their academic qualifications were explored to respond to the question below.

What relationships exist between teachers' stages of concern and their qualifications (or their years of teaching experience)?

The results from a one-way between-groups multivariate analysis of variance (MANOVA), with $p < 0.05$ significance level, showed no significant differences between physical sciences teachers' stages of concern raw scores and their years of experience or their level of educational qualifications. These results differ from those in a study by Puteh *et al.* (2011) who, using a two-way ANOVA, found significant differences in raw scores according to academic qualifications among teachers. However, Puteh *et al.*

(2011) did not reveal at what level their p-values were set. Al-Shabatat (2014) concludes significant differences among participants but does not refer to any statistical analysis such as MANOVA, ANOVA or any p-values. Cruz (2014) did not conduct any statistical analysis to test hypotheses for the study because of the small size of the study sample (8 participants).

The physical sciences teachers' concerns in the Motheo district are not necessarily identified as CAPS challenges because they already existed under NCS and may explain why there were no significant correlations between some of the demographic data (level of education, years of experience with CAPS, years of teaching experience) and the stages of concern raw scores. The majority of the teachers are 'stuck' with some personal concerns and time management concerns which existed before CAPS and until these personal concerns are addressed these teachers would find it challenging to progress to higher stages of concern (George *et al.*, 2013). Thus, these challenges are common to most of the teachers. Therefore, the stages of concern raw scores do not seem to be significantly different among them despite the differences in level of educational qualification or number of years of teaching experience.

5.3.4 Physical sciences teachers' practices and how their concerns and perspectives explain some of these practices

The question that prompted me to explore teachers' classroom practices under CAPS is question five. It stated:

How can physical sciences teachers' practices on some of the new CAPS topics or new sub-topics be described?

In addition, question six prompted me to explore the influence of teachers' concerns and perspectives on their practices.

How do physical sciences teachers' perspectives and concerns influence their classroom practices on the new CAPS topics or sub-topics?

When teachers' concerns were further explored, they emerged as challenges, hence these two questions are better responded to together, to give a holistic picture.

To respond to these questions, I used an open-ended questionnaire and used classroom observations followed by interviews.

The questionnaire stage provided general concerns regarding CAPS. Most teachers were concerned about their uncertainty to meet CAPS demands and were unsure about their role in the implementation of CAPS (personal concerns) and using sources, information, efficiency, organising, managing and scheduling were also dominant among the teachers (management concerns). Exploring these general concerns through interviews and observations further, these emerged as specific challenges such as time constraints, uncertainty about content on new topics in terms of SCK and PCK, workload, insufficient practical skills, large classes and the pressure to produce results.

Apart from time constraints, increased requirements for practical experiments presented challenges on many levels. Some teachers complained of inadequate training and a lack of apparatus. However, on further analysis the problem is related to the fact that physical sciences consist of two subjects that have been combined into one. The demographic data showed that 46.9% of the 81 participants were majors in physical sciences while 28.4% majored in either chemistry or physics, with 7% not majoring in chemistry or physics. However, most of these participants (92%) teach both subjects within physical sciences. Thus, 36% of the 81 physical sciences teachers from the Motheo district who participated in this study spent half of their time teaching content they had not majored in. With new topics in chemistry and physics, such teachers faced challenges in handling these topics, the challenges increasing for practicals in an area one has not majored in. Thus, the time constraints that teachers report may be because of the extra time needed when a teacher is not sure about how to set up an experiment or how to carry out procedures.

Classroom observations on the five participants revealed a complex mixture of traditional and constructivist approaches to teaching and learning. Although some used questions to develop their classes, it was noted that oftentimes the waiting period for the learner responses was short and in most cases, the teachers ended up answering the questions themselves. Responses frequently came from one learner while the class degenerated into a dialogue between that learner and the teacher with the rest

of the class becoming passive. The same applied in the practical lessons that I observed. In some instances, teachers were observed encouraging learners to think in solving problems.

There was evidence of teaching for the examinations, this coincides with Ramatlapana and Makonye (2013: S22) who cited teachers' confirmations that CAPS made them teach for the test as "...drilling and memorization without understanding was encouraged by CAPS". Class experiments were mostly carried out as group or class demonstrations, especially in grades 10 and 12. In the few cases where individual experiments were conducted, the teacher would often come to the workstation and literally take over the experiment from any learners who were stuck, reducing them to mere observers. In most cases, learners would follow prescribed procedures and write a report on the experiment by completing a worksheet. In some cases, the time allocated for an experiment ran out before the learners (and the teacher) were finished with the experiment confirming the time constraints. Cases were observed where the teacher solicited assistance from some learners in carrying out laboratory tasks: retrieving chemicals, equipment and apparatus from the storeroom, setting up experimental stations, removing equipment from workstations after the experiments and cleaning up laboratories.

Interviews and document analysis were used to explore and seek explanations of teacher practice. All the interviewed teachers cited time constraints as the most significant factor in why they become teacher-centred. They cite the packed schedules that they must complete each week, so that there is not time for questioning the learners and probing their responses. Whether classroom practice is learner-centred or teacher-centred was not a priority to most teachers, at least not at the time the study was carried out. The present system seems to be streamlined for efficiency, leaving little room for teachers to be creative in class. Class sizes are still an impediment, especially in grades 10 and 11. While these reasons may have some basis, it is plausible that most teachers had not clearly understood, appreciated the value or the expertise of a constructivist approach in the first place.

The document analysis revealed that teachers did not seem to use the original curriculum documents to interpret or make their own sense of how their practices

should be. Instead, teachers relied on the work schedules developed from the original curriculum documents and the so-called examinable content document and support material from other stakeholders. Instead of teachers making their own sense of the original documents, departmental authorities and other stakeholders seem to be doing most of the sense making on behalf of the teachers by providing teachers with worksheets, notes and laboratory templates all set at the micro level of the curriculum.

This study concludes that the current reform efforts from NCS to CAPS might not have significantly changed teachers' classroom practices, as inferred from their concerns and perspectives. What has changed is policymakers' approach and expectations towards teachers' practice. They have shifted their emphasis to change teachers' practices and seem to conform to a teacher-centred, traditional, content driven approach.

5.4 Recommendations on improving CAPS implementation

This study culminated in the formulation of recommendations and suggestions on improving curriculum implementation in South Africa. These recommendations were found to be complex. Some could have a significant improvement on the implementation of the present reforms. However, some of these recommendations, though reasonable, would not be possible to put into practice without 'repackaging' the present reforms to some extent. Thus, I separated the recommendations into two groups: recommendations aimed at improving physical sciences CAPS implementation and those that could be considered in the next curriculum change cycle.

5.4.1 Recommendations that could enhance physical sciences CAPS implementation

To enhance the implementation of CAPS, the following were recommended by the Motheo district physical sciences teachers:

1. Continuous teacher development targeted at improving physical sciences teachers' subject content knowledge and pedagogical content knowledge
2. Supplying good quality textbooks
3. Continuous staff development targeted at improving physical sciences teachers' laboratory practical skills.

4. Reintroducing the science centres.

While science teachers' lack of PCK and SCK has been reported as impediments to effective teaching (Nakedi, 2014; Basson & Kriek, 2012), these insufficiencies are magnified in times of curriculum reform. In the current context, the teachers deemed the workshops that the authorities provided just before the launch of CAPS as insufficient. Continuous support is more appropriate as opposed to one-time workshops (Dass, 1999; Mokiwa, 2014).

Departmental authorities should invest in developing at least one standard textbook per grade. Teachers indicate that the system has numerous textbooks recommended per grade but none meets the standards. This coincides with findings by Nakedi (2014) who concluded that teachers' efforts to address the NCS science learning outcomes were limited by the poor quality of textbooks. An excellent textbook in times of reforms can assist the teacher and learner in meeting the objectives of the new curriculum, especially where new content and new practical experiments have been added.

The new emphasis on practical experimental work in CAPS is arguably the most significant change in the present reforms to physical sciences teaching. The few workshops that the department provided were deemed insufficient for meeting CAPS demands. Continuous support is necessary if teachers are to become competent enough to meet the new demands.

5.4.2 Recommendations that may require some form of curriculum changes

Research on curricula implementation should expand in such a way that it informs the design of the next curriculum (Penuel *et al.*, 2009). Hence, it was not contradictory that some recommendations and suggestions that emerged because of my interactions with participants in this study only seemed plausible in the context of the next curriculum change cycle. These included:

1. Recommendations to enhance practical work through laboratory technicians.
2. Introducing practical experimental examinations

3. Separating physical sciences into the two respective subjects: chemistry and physics

It is important to point out that CAPS emphasises that learners carry out the individual experiments. This is positive but policymakers have seemingly not accounted well enough for the extra demands this would have on physical sciences teachers' time and expertise.

Apart from their teaching duties, physical sciences teachers are burdened with tasks such as preparing equipment, solutions and reagents for practical science lessons, plus purchasing materials and equipment (Barnea *et al.*, 2010; Mizzi, 2013). These are tasks that in most cases the teachers have little preparation or training in. Setting up a practical experiment, carrying out the experiment with learners as well as cleaning and putting back all the apparatus can be quite challenging in terms of time management and expertise even to the experienced teacher. Managing a well-equipped school science laboratory requires the appropriate expertise and time. The training and employment of laboratory assistants in schools is widely used in countries such as Australia, Canada and the United Kingdom (Barnea *et al.*, 2010; Mizzi, 2013). Besides the general management of high school laboratories and assisting teachers in setting up experiments, suitably qualified laboratory assistants could also be tasked with training teachers in using the new equipment and working with the teacher in charge of science to ensure that the school complies with safety standards (Hackling, 2011: 34).

Retraining teachers in experimental work could also assist in increasing the competency of those teachers who majored in chemistry or physics but not both yet are teaching both topics.

Upon further probing of physical sciences teachers' challenges encountered because of practicals and new topics, some teachers recognise that physical sciences are two subjects that could well be taught as two separate subjects. The challenges to be competent in both chemistry and physics SCK and PCK, and not excluding chemistry and physics practical expertise can only be overwhelming to teachers especially in times of reforms when new topics and increased emphasis on experimental practicals are introduced.

5.5 Implications for practice, policy and further research

The findings in this study have significant implications for curriculum policy formulation and future research. I discuss this below.

5.6.1 Implications and recommendations for policy

Well-planned efforts should accompany future reforms to determine teachers' concerns at different periods of the implementation. Strategies could then be formulated to enhance and address these concerns and in that process, enhance curriculum implementation. Previous challenges should be well documented and strategies should be developed to avoid pitfalls in the previous implementations. Periodically conducting the stages of concern questionnaire with physical sciences teachers is recommended for future research. Each time the questionnaire is conducted and interpreted; this should be followed by the development of strategies based on these interpretations, with the aim of addressing those concerns. Interpreting these group and individuals' profiles should be carried out within the context of the dynamics that could be at play in physical sciences teachers' practices.

5.5.2. 'Decentralising' curriculum changes in South Africa

While there are fundamentals about a national curriculum that should be common to all subjects, such as the philosophical basis of what a good education entails, the role of the teacher and the role of the learner, subject disciplines differ in many ways. Thus, curriculum changes could be carried out on two levels: change in the fundamentals and secondly, changes in the specific subjects. The second change is addressed as "decentralising". Policymakers could consider decentralising curriculum changes in subject disciplines. Changes in curricula across subjects can be done in respective subjects independently and at different times.

This would reduce the large amount of change the system undergoes at a time. For physical sciences, this would mean small changes across the years in terms of content changes in line with science research findings. Science is ever shifting due to research; hence, what constitutes "true science" today may not necessarily be so true two years from now in a fast-changing, research driven 21st century. These research findings do not have to be put on hold until the next curriculum cycle, which may be 10 years from

now. Small changes or adjustments in content over the years are less likely to put a lot of pressure on teachers to update their SCK or their PCK, as opposed to waiting for ten years then expecting teachers to update their knowledge domains in a short period.

5.5.3 Implication for future research

Although researchers conducting studies into the effectiveness of curriculum programmes do analyse the dynamics discussed in chapter two, implementation researchers rarely focus on changing the dynamics that inhibit implementation effectiveness (Penuel & Fishman, 2012). Research could be directed at these dynamics and how best to minimise their negative impact on the implementation process. Further research could focus on exploring the relationships between curriculum implementation dynamics and physical sciences teachers' concerns.

5.5.4 The role of implementation research

My experiences throughout this study have generated some questions concerning the role of implementation researchers. The first major question is what is the role of implementation researchers? Should it solely be confined to probing the successful implementation of reforms, irrespective of the quality? Alternatively, should implementation researchers evaluate and support the kind of innovations that align with what methodological researchers consider the best classroom practice?

If education reforms of the past four decades have been characterised by great ambitions culminating in modest results in changing teacher classroom practices (Cohen, 1990; Rowan & Guthrie, 1989), current CAPS reforms can be described as lacking such ambition. Most reforms of the past four decades have mostly been to encourage a shift towards a constructive, learner-centred culture in the classroom (Cohen, 1990; Piburn *et al.*, 2000). Earlier evaluations on CAPS have revealed an opposite shift towards a much more traditional approach with limited freedom for teachers to make their own sense of the curriculum (Ramatlapanana & Makonye, 2013).

The findings from UMALUSI (2014) cite the tendency towards a more traditional content and examination driven curriculum. With regard to physical sciences, the report points out prescribed activities and timeframes. This does not leave the teacher with much room to be creative or to create a teaching environment that takes cognisance of learners' particularities. Teaching programmes have been provided for teachers with

the clear, overriding assumption that educators lack expertise. A study by Ramatlapana and Makonye (2013: 8) echoes similar findings, pointing out that the CAPS curriculum is “quite prescriptive to the point of demanding uniformity in implementation across the nation”, adding that topics and concepts to be taught are explicitly delimited, leaving no room for flexibility and no appreciable freedom for teachers. In the Motheo district, physical sciences teachers are provided with two documents: the examinable content document and the schedules to which they strictly adhere to and through which the curriculum materials have been interpreted on their behalf. Teachers must not be regarded as merely curriculum implementers but are also expected to make their own sense and meaning of the national curriculum guidelines (Jita & Mokhele, 2013).

The curriculum representations discussed different levels at which curricula may be organised (cf. section 2.3). The CAPS curriculum is organised at the meso and the micro level (UMALUSI, 2014), the micro level being the space where teachers should be able to make their own sense of the curriculum, interpret curriculum documents, plan their lessons, and execute their classroom duties in accordance with the context and the background of their learners. The authorities may have developed such an instructional programme to assist those teachers who might not be competent enough to cope with the demands of teaching the physical sciences. However, in that effort they may have stifled creativity among those teachers who are competent (UMALUSI, 2014).

While no reform programme is without its shortcomings and while I recognise some positive improvements in the CAPS curriculum such as clarity in assessment objectives, the above issues revolving around the role of the teacher warrants attention from all stakeholders as they might be considered counter progressive, considering research findings of the past decades. These research findings should inform policies that will subsequently influence practice. If implementation research of recent times has bemoaned the fact that good programmes are being poorly implemented (Cuban, 1998; Fullan, 1993; Spillane, 1999; Lopez & Wise, 2015), the reverse, where poorly designed programmes are well implemented is not a better option. In fact, it could be a worse option – a situation where practice influences policy instead of policy influencing practice (Cohen, 1990).

5.6 Limitations of the study

Although this study provides significant insight into teachers' concerns and perspectives during the implementation of CAPS and although it reveals the relationships that exist between implementing reforms and variables such as level of experience, limitations are inevitable. This study may yield biased results because it was carried out using teachers in one district. There may be discrepancies among districts that might limit the generalisation of the findings to the whole province or to South Africa. However, to offset this limitation, participants were taken from a wide range of backgrounds that nearly approached the representation of the South African landscape. The weaknesses that often accompany surveys could not be avoided in this study. Survey limitations stem from the fact that they depend on what the researcher seeks to understand, gives priority to and asks. Surveys are also only as good as the frankness of the respondents and their ability to respond. However, these limitations were reduced in two significant ways. Firstly, by using a survey instrument developed and validated by other professional researchers and secondly, by following up and exploring these tentative findings from the survey data further through observations, document analysis and interviews. Thus, in the end, multiple sources of data were used and these were triangulated to give integrated findings.

5.7 Conclusions

The post-1994 South African education system has witnessed the enactment of reforms with the literature revealing that challenges have been encountered during the implementation stages of recent curriculum change efforts (Jansen, 1999; Rogan, 2000; Rogan & Grayson, 2003). The current reforms in the form of CAPS were introduced to improve the implementation of the previous NCS (DBE, 2011). While teachers have been identified as playing a central role in the implementation of reforms, there is a scarcity of studies exploring teachers' perspectives during times of curriculum change. The use of mixed methods and CBAM to explore teachers' concerns offers great possibilities to understand the complexities of curriculum implementation through the eyes of teachers. Neither the qualitative nor the quantitative approach alone would be sufficient to explore such complex terrain completely and satisfactorily. The present study broadens knowledge horizons using

mixed methods and CBAM in a robust combination of methodological approaches employed to comprehend teachers' concerns during curriculum changes.

Since the 1970s when the implementation gap between policymakers' vision and the actual identified change, implementation research has evolved with the aim of reducing this gap. This is done by addressing the dynamics or obstacles that reduce, maintain or enlarge that gap (Brown & Campione, 1996; Brown & Edelson, 2001; Cordray & Pion, 2006; Sarason, 1990; Fullan 1993; Cuban 1998; Spillane, 1999; Lopez & Wise, 2015). In South Africa, some of the challenges influencing curriculum implementation include what some educators perceived as the political agendas of stakeholders, the demand for a new educator role, bottom-up versus top-down processes, teacher workloads and teachers as central agents of implementation. Additional challenges include teachers' identities during times of change, contradictory messages from authorities before and during reform implementation, the philosophy or worldview behind curriculum reform and lastly, the impact (on teachers) of the general and socioeconomic conditions before and during reform implementation (Treu *et al.*, 2010). The literature review revealed that despite the influence of these dynamics in reducing, maintaining or enlarging the implementation gap, implementation researchers dedicate minimal efforts towards finding strategies to minimise the negative impact of these dynamics on the implementation process (Treu *et al.*, 2010). While some progress has been made in the field of education reforms and implementation in South Africa, some dynamics that negatively influenced earlier post-apartheid reform efforts still need to be addressed by policymakers before launching new reforms. Aspects indicating positive progress during the present reform cycle include the reduced influence of different political agendas that characterised the introduction of C2005, as reported by some academics (Jansen, 1999, Chisholm, 2003). Generally, physical sciences teachers who participated in the present study had higher level of education than the teachers who were in the system when earlier reforms were introduced (Basson & Kriek, 2012).

The Motheo district physical sciences teachers' concerns and perspectives overlap and intertwine with some of the dynamics listed above. These include teachers' workloads and time constrains, the demand for a new educator role, teachers as

central agents of implementation, teachers' insufficient SCK and PCK, and insufficient practical skills.

In this study, I classify teachers' perspectives during reform implementation into two groups: those based on "innovation expectations" are perspectives that teachers express in the hope that the new curriculum will resolve some of their concerns they might have experienced in the previous curriculum while the second group of perspectives are based on "innovation experiences". These are perspectives based on teachers' experience with the innovation. When teachers' positive perspectives are based solely on their expectations that the innovation will resolve some concerns, these may transform into obstacles if the new reform does not live up to those expectations.

Increased workloads, time constraints, the lack of appropriate textbooks, large classes and teachers' deficiencies in experimental practical expertise, pedagogical content knowledge and subject content knowledge are some of the challenges highlighted by physical sciences teachers in this study.

This study reveals that the nature of physical sciences as a combination of two subjects, chemistry and physics, presents challenges. Some teachers only majored in one of the two subjects but still find themselves teaching both. This highlights problems including deficient pedagogical content knowledge, a lack of expertise in some practical and experimental areas to poor levels of content knowledge. These deficiencies exacerbate time pressure even though the deficiencies are rooted in other issues, for example a lack of knowledge about setting up experiments.

Most of the physical sciences teachers in the Motheo district were at the unconcerned stage of CAPS implementation. A high score on the unconcerned stage indicates that the participants are probably more concerned about other tasks and activities. Further exploration using interviews and observations revealed that these personal concerns were also in existence during teachers' experience with the previous NCS curriculum. The CAPS curriculum may have only magnified these concerns with the introduction of new topics and sub-topics and most teachers seem to be 'stuck' at this stage until these concerns are addressed. The responsible authorities should develop and apply

appropriate interventions to address these concerns and encourage teachers to implement CAPS more effectively.

The perspectives and the concerns expressed by the physicals sciences teachers who participated in the qualitative influenced their classroom practices in different ways which were not always in alignment with the best classroom practices. Most teachers used a combination of teacher centred and learner centred approaches. In most cases, time constrains were cited as impeding the use of learner centred approaches. Classroom demonstrations were widespread where individual experiments had been recommended according to curriculum documents. Notes, worksheets, laboratory report templates and other curriculum materials were made available to teachers by the subject advisors and other stakeholders who were working independently or in partnership with the Free State Department of Basic education.

This study concludes that the current reform efforts from NCS to CAPS might not have significantly changed teachers' classroom practices, as inferred from their concerns and perspectives. What has changed is policymakers' approach and expectations towards teachers' practice. They have shifted their emphasis to change teachers' practices and seem to conform to a teacher-centred, traditional, content driven approach.

Several recommendations emerged because of the findings of this study. The increased emphasis on practical experiments in the present curriculum changes is a positive development but only if it is not limited by the lack of expertise of teachers in practical work. Retraining teachers for experimental work is a recommendation that could enhance the implementation of the present reforms. Staff development in assisting teachers to update their SCK and PCK should not be limited to one-time workshops at the launch of the new reforms but should be continuous. Some recommendations may require some form of curriculum change. The employment of laboratory assistants could be a positive step in enhancing and fulfilling the present emphasis on hands-on experiments for the science learners. When this is achieved, future reforms in science education may require that learners carry out experiments as part of their examinations. Policymakers may consider separating physical sciences

as a subject into its two distinct disciplines of chemistry and physics in the next reform cycle.

Thus, through the literature review, I analysed how past curriculum implementation experiences have shaped the present implementation efforts, and through the analysis of results I described and explained how Motheo district physical sciences teachers were implementing CAPS. Through the recommendations, which were based on documented past implementation experiences and the findings presented in this thesis, my study broadens implementation research in such a way that it informs the design of the next curriculum in the Republic of South Africa.

References

- Aikenhead GS 2007. Humanistic perspectives in the science curriculum. In S.K. Abell & N.G. Lederman (Eds.). *Handbook of research on science education*. Mahwah, NJ: Lawrence.
- Al-Shabatat, A.M. 2014. Gifted teachers' stages of concerns for integrating e-learning in the gifted schools in Jordan. *Turkish online Journal of Education Technology*, 13(2): 80–87.
- Adu, E.O. & Ngibe, N.C.P. 2014. Continuous change in curriculum: South African teachers' perceptions. *Mediterranean Journal of Social Sciences*, 5(23): 983-989.
- Arzi, H.J. & White, R.T. 2007. Change in teachers' knowledge of subject matter: A 17-year longitudinal study. *Science Education*, 92: 221-251.
- Atkinson, P. & Hammersley, M. 1994. "Ethnography and participant observation." In NK Denzin and YS Lincoln (Eds.) *Handbook of Qualitative Research* (pp. 248-261). Thousand Oaks: Sage Publications.
- Barnea, N., Dori, Y.J. & Hofstein, A. 2010. Development and implementation of inquiry-based and computerized-based laboratories: Reforming high school chemistry in Israel. *Chemistry Education Research and Practice*, 11(3): 218-228.
- Barnes, M., Clarke, D. & Stephens, M. 2000. Assessment: the engine of systemic curricular reform? *Journal of Curriculum Studies*, 32(5): 623-650.
- Basson, I. & Kriek, J. 2012. Are grades 10-12 physical sciences teachers equipped to teach physics? *Perspectives in Education*, 30(3): 110-121.
- Becker, M.K. 2011. Teachers' concerns regarding the implementation and continued use of an evidenced-based educational practice. Unpublished PhD thesis. Florida: University of Florida.
- Bell, B. & Gilbert, J. 1996. *Teacher development: A model from science education*. London: Falmer.
- Ben-Zvi, R., Eylon, B., & Silberstein, J. 1987. Students' visualization of a chemical reaction. *Education in Chemistry*, 117-120.

- Bernstein, B. 1996. *Pedagogy, symbolic control and identity: Theory, research, critique*. London: Taylor & Francis.
- Bennie, K. and Newstead, K. 1999. Obstacles to implementing a new curriculum. In M.J. Smit & A.S. Jordaan (Eds.), *Proceedings of the National Subject Didactics Symposium*, Stellenbosch: University of Stellenbosch. pp. 150-157.
- Berg, B. 2007. *Qualitative research methods for the social sciences*, 6th ed. Boston: Pearson Education.
- Berman, P., & McLaughlin, M. 1976. Implementation of educational innovations. *Educational Forum*, 40, 345-370.
- Blumenfeld, P., Fishman, B. J., Krajcik, J., Marx, R. W., & Soloway, E. 2000. Creating usable innovations in systemic reform: Scaling up technology-embedded project based science in urban schools. *Educational Psychologist*, 35(3), 149-164.
- Bogdan, R. C., & Knopp Biklen, S. 2006. *Qualitative research for education. An introduction to theories and methods*, 5th ed. Boston: Pearson.
- Bond, G. R., Evans, L., Salyers, M. P., Williams, J., & Kim, H. W. 2000. Measurement of fidelity in psychiatric rehabilitation. *Mental Health Services Research*, 2(2), 75–87.
- Borko, H., & Putnam, R. T. 1996. Learning to teach. In R.C. Calfee & D.C. Berliner (Eds.), *Handbook of educational psychology*. New York, NY: Macmillan.
- Brewer, J. & Hunter, A. 1989. *Multimethod research: A synthesis of styles*. Newbury Park: Sage Publications.
- Brewer, W. F., & Nakamura, G. V. 1984. The nature and functions of schemas. In R.S. Wyer & T.K. Srull (Eds.), *Handbook of social cognition*. Hillsdale, NJ: Erlbaum. pp. 119-160.
- Bridgart, G.J. & Kemp, H.R. 1985. A limitation on the use of Le Châtelier's principle. *The Australian Science Teachers Journal*, 31(2): 60-62.

- Brown, A.L. & Campione, J. 1996. Psychological theory and the design of innovative learning environments: On procedures, principles and systems. In L. Schauble & R. Glaser (Eds.). *Innovations in learning: New environments for education*. Hillsdale, NJ: Erlbaum. (pp 289-325).
- Brown, M.W. & Edelson, D.C. 2001. Teaching by design: Curriculum design as lens on instructional practice. *Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.*
- Carey, S. 1985. *Conceptual change in childhood*. Cambridge, MA: Bradford.
- Çetinkaya, B. 2012. Understanding teachers in the midst of reform: Teachers' concerns about reformed sixth grade mathematics curriculum in Turkey. *Eurasia Journal of Mathematics, Science and Technology Education*, 8(3): 155-166.
- Cherryholmes, C.H. 1992. Notes on pragmatism and scientific realism. *Educational Researcher*, 21(6): 13-17.
- Chisholm, L., Volmink, J., Ndhlovu, T., Potenza, E., Mahomed, H. & Muller, J. 2000. A South African curriculum for the twenty first century. *Report of the review committee on Curriculum 2005, Pretoria, 31 May 2000*. Pretoria: Department of Education.
- Christou, C., Eliophotou-Menon, M. & Phillippou, G. 2004. Teachers' concerns regarding the adoption of a new mathematics curriculum: An application of CBAM. *Educational Studies in Mathematics*, 57: 157-176.
- Cohen, L., Manion, L., & Morrison, K. 2007. *Research methods in education*. London: RoutledgeFalmer
- Cohen, D.K. 1990. A revolution in one classroom: The case of Mrs. Oublier. *Educational Evaluation and Policy Analysis*, 12(3), 311-329.
- Colman, A. M. 2015. *A dictionary of psychology*, 4th ed. Oxford: Oxford University Press.
- Combs, J.P. & Onwuegbuzie, A.J. 2010, Describing and illustrating data analysis in mixed

research. *International Journal of Education*, 2(2): 1–23.

- Cordray, D. & Pion, G.M. 2006. Treatment strength and integrity: Models and methods. In R.R. Bootzin & P.E. Mcknight (Eds.). *Strengthening research methodology: Psychological measurement and evaluation*. Washington, DC: American Psychological Association. pp. 103-124.
- Creswell, J.W. 2009. *Research design: Qualitative and quantitative approaches*, 3rd ed. London: Sage Publications.
- Creswell, J.W. & Plano Clark, V.L. 2011. *Designing and conducting mixed methods research*, 2nd ed. London: Sage Publications.
- Creswell, J.W. & Clark, V.L.P. 2007, *Designing and conducting mixed methods research*. Thousand Oaks: Sage Publications.
- Creswell, J.W. 2005. *Educational research: planning, conducting, and evaluating quantitative and qualitative research*, 2nd ed. New Jersey: Pearson/Merrill Prentice Hall.
- Creswell, J.W. 2013. *Qualitative inquiry and research Design: Choosing among the five approaches*, 3rd ed. Los Angeles, CA: Sage Publications.
- Creswell, J. W. 2014. *Qualitative inquiry and research design: Choosing among the five approaches*, 4th ed. Los Angeles: Sage.
- Cruz, J. 2014. The effect of change facilitation coaching using the concerns-based adoption model with an urban elementary school teacher-leadership team. Unpublished PhD thesis. Phoenix: Arizona State University.
- Cuban, L. 1998. How schools change reforms: Redefining reform success and failure. *Teachers College Record*, 99(3):453–477.
- Dane, A.V. & Schneider, B.H. 1998. Program integrity in primary and early secondary prevention: Are implementation effects out of control? *Clinical Psychology Review*, 18 (1): 23-45.

- Dass, P.M. 1999. Evaluation of a District-wide In-service Professional Development Program for Teaching Science: Challenges Faced and Lessons Learned. *Electronic Journal of Science Education*, 4:1-19.
- Department of Education 1997. Curriculum 2005: A policy framework. Pretoria: Government Printer
- Department of Basic Education. 2011. Curriculum and Assessment Policy Statement CAPS: Physical Sciences. Pretoria: Government Printers.
- Department of Education. 2007. National Curriculum Statement Grades 10-12 subject assessment guidelines physical sciences. Pretoria: Department of Education.
- Department of Education (DoE). 2006. National curriculum statements grades 10-12 (general) physical sciences content. Pretoria: Government Publishers.
- Desimone, L. 2002. How can comprehensive school reform models be successfully implemented? *Review of Educational Research*, 72: 433-479.
- Dudu, W. T. 2014. The changing roles of South African natural science teachers in an era of introducing a "Refined and Repackaged " curriculum. *International Journal Of Educational Sciences* , 7(3), 547–558.
- Dusenbury, L., Brannigan, R., Falco, M. & Hansen, W.B. 2003. A review of research on fidelity of implementation: Implications for drug abuse prevention in school settings. *Health Education Research*, 18(2), 237-256.
- Eggen, P., & Kauchak, D. 1999. *Educational psychology*, 4th ed. Upper Saddle River, NJ: Merrill.
- Fataar, A. 2000. Education. *Policy in South Africa in socio-historical context: Continuities and discontinuities*. Cape Town: Faculty of Education, UWC).

- Fink, D. L. 2003. *Creating Significant Learning Experiences: an integrated Approach to Designing College Courses*. San Francisco: Jossey-Bass.
- Fullan, M. 1993. *Change forces: Probing the depths of education reform*. London: The Falmer Press.
- Fuller, F.F. 1969. Concerns of teachers: A developmental conceptualization. *American Educational Research Journal*, 6(2): 207-226.
- George, A.A., Hall, G.E., Stiegelbauer, S.M. & Litke, B. 2006. *Stages of concern questionnaire online Computer software, SEDL, Austin*. Available at <http://www.sedl.org/pubs/catalog/items/cbam21.html> [Accessed 22 August 2015].
- George, L.J. 2015. *Concerns of elementary school leaders and teachers when implementing a common core aligned mathematics program*. Available at <http://surface.syr.edu/etd/209> [Accessed 20 August 2015].
- Gorman, G. E., & Clayton, P. 2005. *Qualitative research for the information professional*, 2nd ed. London: Facet.
- Goodlad, J.I. 1994. *Educational renewal: Better teachers, better schools*. San Francisco, CA: Jossey-Bass.
- Graven, M. 2002. The effect of the South African curriculum change process on mathematics teacher roles. In P. Valero & O. Skovsmose. *Proceedings of the 3rd International MES conference, research in learning mathematics*, Copenhagen. pp. 1–10.
- Greene, J.C., Caracelli, V.J. & Graham, W.F. 1989. Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis*, 11(3): 255-274.
- Greeno, J.G., Collins, A.M. & Resnick, L.B. 1996. Cognition and learning. In D.C. Berliner & R.C. Calfee (Eds.). *Handbook of educational psychology*. New York: Macmillan Library Reference USA. (pp. 15-46).

- Griffiths, A.K., & Preston, K.R. 1992. Grade-12 students' misconceptions relating to fundamental characteristics of atoms and molecules. *Journal of Research in Science Teaching*, 29(6), 611 - 628.
- Grossman, P. L. 1990. *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.
- Guba, E. G. (Ed.). 1990. *The paradigm dialog*. Newbury Park, CA: Sage.
- Guba, E.G. 1981. Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology Journal*, 29: 75-91.
- Hackling, M., Peers, S., &Prain, V. 2007. Primary connections: Reforming science teaching in Australian primary schools. *Teaching Science*, 53(3), 12-16.
- Hall, B.G.E. & Hord, S.M. 2011. Implementation: Learning builds the bridge between research and practice. *Journal of Staff Development*, 32(4): 52-57.
- Hall, G. E., & Hord, S. M. 1987. *Change in schools: Facilitating the process*. Albany, NY: State University of New York. Hall, G.E. & George, A.A. 2013. Examining relationships between urban principal change facilitator style and student learning. *International Journal of Leadership and Change*, 1(1): 36-46.
- Hall, E. & Hord, S.M. 2015. *Implementing change: Patterns, principles and potholes*, 4th ed. Upper Saddle River, NJ: Pearson.
- Hall, G., George, A., & Rutherford, W. 1998. *Measuring Stages of Concern about Innovation: A Manual for use of the SoC Questionnaire*. Austin, TX: Southwest Educational Development Laboratory.
- Hancock, B., Windridge, K. & Ockleford, E. 2009. *An introduction to qualitative research*. Yorkshire: The NIHR DSEM/YM.
- Hashweh, M.Z. 2005. Teacher pedagogical constructions: A reconfiguration of pedagogical content knowledge. *Teachers and Teaching: Theory and Practice*, 11(3): 273-292.

- Heidegger, M. 2002. *The essence of truth* (Translated from the German by Sadler, T.). New York, NY: Continuum.
- Hunter, D.J. & Marks, L. 2002. *Decision-making process for effective policy implementation*. Wolfson Research Institute: University of Durham Queens Campus.
- Husserl, E. 1975. *The Paris lectures* (P. Koesterbaum, Trans.). The Hague: Martinus Nijhoff
- Hirsch, E. D. J. 2001. Seeking breadth and depth in the curriculum. *Educational Leadership*, 59(2), 22–25.
- Hofstein, A., & Walberg, H. J. 1995. Instructional strategies. In B. J. Fraser & H. J. Walberg (Eds.), *Improving science education*. Chicago: National Society for the Study of Education.
- Holloway, K. 2003. A measure of concern: Research-based program aids by addressing teacher concerns. *Tools for Schools*, 6(4): 1-8.
- Hord, S.M., Rutherford, W.L., Huling-Austin, L. & Hall G.E. 1998. *Taking charge of change*. Austin: Southwest Educational Development Library.
- Hord, S.M., Stiegelbauer, S.M., Hall, G.E., & George, A.A. 2006. Measuring implementation in schools: Innovation configurations. Available at: <http://www.sedl.org/pubs/catalog/items/cbam19.html> [Accessed 20 August 2015]
- Isbell, L.J. 2013. Secondary teachers' concerns about response to intervention: Using the concerns-based adoption model.
- Jansen, J. & Taylor, N. 2003. *Educational change in South Africa 1994-2003: Case studies in large-scale education reform*. *Education Reform and Management Publication Series Vol. II No. 1 October 2003*. Available at http://www.jet.org.za/publications/research/Jansen%20and%20Taylor_World%20Bank%20report.pdf. [Accessed 11 October 2015].
- Jansen, J.D. 1998. Curriculum reform in South Africa: A critical analysis of outcomes-based education. *Cambridge Journal of Education*, 28(3): 321–331.

- Jennings, S.T. 2015. What concerns are secondary mathematics teachers experiencing with the implementation of the common core state standards for mathematics and is there a relationship between the concerns and professional development received? Unpublished PhD thesis. Mississippi: University of Mississippi.
- Jita, L.C. & Mokhele, M.L. 2013. The role of lead classroom teachers in instructional leadership: A case study of environmental learning in South Africa. *Education as Change*, 17(1): 123-135.
- Johnson, B., & Onwuegbuzie, A. 2006. Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, 33(7), 14-26.
- Katz, L. G., & Rath, J. 1992. Six dilemmas in teacher education. *Journal of Teacher Education*, 43(5), 376 – 385.
- Koopman, O., Le Grange, L.L, & De Mink, K. 2016. A narration of a physical science teacher's experience of implementing a new curriculum. *Education as Change*, 20(1), 435-452.
- Krajcik, J., Mamlok, R., & Hug, B. 2000. Learning science through inquiry. In L. Corno (Ed.), *Education across a century: The central volume* (One Hundredth Yearbook of the National Society for the Study of Education, NSSE) (pp. 205–238). Chicago: National Society for the Study of Education.
- Kriek, J & Grayson, D. 2009. A holistic professional development model for South African physical science teachers. *South African Journal of Education*, 29, 185-203.
- Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago: University of Chicago Press.
- Le Grange, L., & Reddy, C. 2000. Introducing educators to OBE: a Western Cape case study. *South African Journal of Education*, 20, 21–25.
- Lee, J.C & Yin, H. 2011. *Teachers' emotions and professional identity in curriculum reform: A Chinese perspective*. Published *J Educ Change* (2011) 12:25–46
- Leinhardt G & Greeno J G 1986. The cognitive skill of teaching. *Journal of Educational Psychology*, 78:75-95.

- Lincoln, Y.S & Guba, E.G. 1985. *Naturalistic inquiry*. Beverly Hills: Sage Publications.
- Liu, C.H. & Matthews, R. 2005. Vygotsky's philosophy: Constructivism and its criticisms examined. *International Education Journal*, 6(3), 386-399.
- Lobato, J., Rhodehamel, B., & Hohensee, C. 2012. 'Noticing' as an alternative transfer of learning process. *Journal of the Learning Sciences*, 21, 433–482.
- McDonald, R. & Van der Horst, H. 2007. Curriculum alignment, globalization, and quality assurance in South African higher education. *Journal of Curriculum Studies*, 39 (1): 1-9.
- McGrath, S. (2000). Coming in from the cold? Further education and training in South Africa. *Compare*, 30, 68–84.
- Manouchehri, A. & Goodman, T. 2000. Implementing mathematics reform: The challenge within. *Educational Studies in Mathematics*, 42: 1-34.
- Mansour, N., EL-Deghaidy, H., Alshamrani, S. & Aldahmash, A. 2014. Rethinking the theory and practice of continuing professional development: Science teachers' perspectives. *Research in Science Education*, 44(6), 949-973.
- Marsh, C. J. and Willis, G. 2003. *Curriculum Alternative Approaches, Ongoing Issues*, 3rd ed. Upper Saddle River, NJ: Pearson Education.
- Maxcy, S. J. (2003). Pragmatic threads in mixed methods research in the social sciences: the search for multiple modes of inquiry and the end of the philosophy of formalism. In A. Tashakkori & C. Teddlie (Eds) *Handbook of Mixed Methods in Social and Behavioral Research*. Thousand Oaks, CA.: Sage.
- Merriam, S.B.1998. *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.
- Mihalic, S. 2002. *The importance of implementation fidelity*. Boulder, CO: Center for the Study and Prevention of Violence.

- Miles, M.B. & Huberman, A.M. 1994. *Qualitative data analysis*, 2nd ed. Newbury Park: Sage Publications.
- Mills, J., Bonner, A. & Francis, K. 2006. The development of constructivist grounded theory. *International Journal of Qualitative Methods*, 5(1): 1-10.
- Mizzi, D. 2013. The challenges faced by science teachers when teaching outside their specific science specialism. *Acta Didacta Naposcensia*, 6:4
- Mokiwa, H.O. 2014. Exploring the teaching of physical science through inquiry. *International Journal of Education Sciences*, 7(1): 21-27.
- Moodley, G. 2013. *Implementation of the curriculum and assessment policy statements: Challenges and implications for teaching and learning*. Available at <http://hdl.handle.net/10500/13374> [Accessed 27 August 2015].
- Morgan, D. L. 2007. Paradigms lost and pragmatism regained. Methodological implications of combining qualitative and quantitative methods. *Journal of Mixed Methods Research*, 1, 48–76.
- Morse J.M. & Niehaus L. 2009. *Mixed method design: Principles and procedures*. Walnut Creek, CA, USA: Left Coast Press Inc.
- Mulhall A. 2003. In the field: notes on observation in qualitative research. *Journal of Advanced Nursing*, 41(3): 306-313.
- Murphy, J.P. 1990. *Pragmatism: from Peirce to Davidson*. Boulder, CO: Westview Press.
- Nakedi, E.M. 2014. Physical science teachers' responses to curriculum challenges in South Africa: pedagogical content knowledge focused case studies. Unpublished PhD thesis. Johannesburg: University of the Witwatersrand.
- Nakedi, M., Taylor, D., Mundalamo, F., Rollnick, M. & Mokeleche, M. 2012. The story of a physical science curriculum: Transformation or transmutation? *African Journal of Research in Mathematics, Science and Technology Education* 16(3): 273-288.

- Nawastheen, F.M., Puteh, S.N. & Meerah, T.S.M. 2014, 'Teachers' levels of use of the 5e instructional model in the implementation of curriculum reforms in Sri Lanka', *Research Journal of Applied Sciences, Engineering and Technology* 7(17), 3561–3570.
- Newmann, F. M. (1988). Can depth replace coverage in the high school curriculum? *Phi Delta Kappan*, 69(5), 345 – 348.
- Nkosi, T.P. 2014. Teachers' experiences of the implementation of the Curriculum and Assessment Policy Statement: A case study of three primary schools in KwaZulu-Natal Province. Unpublished Master's dissertation. Durban: University of KwaZulu-Natal.
- O'Donnell, C.L. 2008. Defining conceptualization and measuring fidelity of implementation and its relationship to outcomes in K-12 curriculum intervention research. *Review of Educational Research*, 78(1): 33-84.
- Olsen ME, Lodwick DG, Dunlop RE 1992. *Viewing the world Ecologically*. Boulder, CO: Westview Press.
- Onwuegbuzie, A.J. & Combs, J.P. 2010. Emergent data analysis techniques in mixed methods research: A synthesis. In A. Tashakkori & C. Teddlie (Eds.). *Handbook of mixed methods in social and behavioral research*, 3rd ed. Thousand Oaks, CA: Sage Publications. pp. 397-430.
- Onwuegbuzie, A.J., Johnson, R.B. & Collins, K.M.T. 2009. A call for mixed analysis: A philosophical framework for combining qualitative and quantitative. *International Journal of Multiple Research Approaches*, 3: 114-139
- Ozturk, I.H. 2011. Curriculum reform and teacher autonomy in Turkey: The case of the history teaching. *International Journal of Instruction*, 4(2): 113-128.
- Patton, M.Q. 2002. *Qualitative research & evaluation methods*, 3rd ed. London: Sage Publications.

- Penuel, W. R., Frank, K. A., Fishman, B. J., Sabelli, N., & Cheng, B. 2009. *Expanding the scope of implementation research in education to inform design*. Menlo Park, CA: SRI International.
- Penuel, W.R., Phillips, R.S. & Harris, C.J. 2014. Analysing teachers' curriculum implementation from integrity and actor-oriented perspectives *Journal Curriculum Studies*, 46(6): 751-777.
- Phage, I. B. 2015. An analysis of students' knowledge of graphs in mathematics and kinematics. Unpublished Master's dissertation. Potchefstroom: North West University.
- Phillips, D.C. & Burbules, N.C. 2000. *Post positivism and educational research*. New York: Rowman & Littlefield.
- Piburn, M., Sawada, D., Turley, J., Falconer, K., Benford, R., Bloom, I. & Judson, E. 2000. *Reformed teaching observation protocol (RTOP): Reference manual (ACEPT Technical Report No. IN00-3)*. Tempe, AZ: Arizona Collaborative for Excellence in the Preparation of Teachers.
- Pitts, J.M. 1994. Personal understandings and mental models of information: a qualitative study of factors associated with the information-seeking and use of adolescents. Unpublished PhD thesis. Florida: Florida State University.
- Punch, K.F. 2005. *Introduction to social science: Quantitative and qualitative approaches*. London: Sage Publications.
- Puteh, S.N., Salam, K.A.A. & Jusoff, K. 2011. Using CBAM to evaluate teachers' concerns in science literacy for human capital development at the preschool. *World Applied Sciences Journal*, 14: 81-87.
- Ramatlapana, K. & Makonye, J.P. 2013. From too much freedom to too much restriction: The case of teacher autonomy from National Curriculum Statement (NCS) to Curriculum and Assessment Policy Statement (CAPS). *Africa Education Review*, 9(1): 7–25.

- Raselimo, M. & Wilmot, D. 2013. Geography teachers' interpretation of a curriculum reform initiative: the case of the Lesotho Environmental Education Support Project (LEESP). *South African Journal of Education*; 2013; 33(1).
- Remillard, J. T. 2005. Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research* 75(2), 211–246.
- Resnick LB 1987. *Education and learning to think*. Washington DC: National Academy Press.
- Riffel, A.D. 2015. An Insight into a school's readiness to implement a CAPS related indigenous knowledge curriculum for meteorological sciences. *Universal Journal of Educational Research* 3(11): 906-916.
- Rocco, T. S., Bliss, L. A., Gallagher, S., Perez-Prado, A., Alacaci, C., Dwyer, E. S., Fine, J. C., & Pappamihiel, N. E. 2003. The pragmatic and dialectical lenses: Two views of mixed methods use in education. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research*. Thousand Oaks, CA: Sage. pp. 595–615.
- Roehrig, G.H. & Kruse, R.A. 2005. The role of teachers' beliefs and knowledge in the adoption of a reform-based curriculum. *School Science and Mathematics*, 105: 412-422.
- Rogan, J. 2000. Strawberries, cream and the implementation of curriculum 2005: Towards a research agenda. *South African Journal of Education*, 20: 118–125.
- Rogan, J. 2007a. How much curriculum change is appropriate? Defining a zone of feasible implementation. *Science Education*, 91: 439–460.
- Rogan, J. 2007b. An uncertain harvest: A case study of implementation of innovation. *Journal of Curriculum Studies*, 39: 97-121.
- Rogan, J.M. 2004. Out of the frying pan? Case studies of the implementation of curriculum 2005 in some science classrooms. *African Journal of Research in Mathematics, Science and Technology Education*, 8: 165-179.

- Rogan, J. & Aldous, C. 2005. Relationships between the constructs of a theory of curriculum implementation. *Journal of Research in Science Teaching*, 42: 313-336.
- Rogan, J.M. & Grayson, D.F. 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.
- Rorty, R. 2000. *The decline of redemptive truth and the rise of literacy culture*. Available at olicecenter.uchicago.edu/pdf/rorty.pdf [Accessed 27 August 2015].
- Rossmann, G.B. & Wilson, B.L. 1995. Numbers and words: Combining qualitative and quantitative methods in a single large scale research study. *Evaluation Review* 9(5): 627–643.
- Rowan, B., & Miller, R. J. 2007. Organizing strategies for promoting instructional change: Implementation dynamics in schools working with comprehensive school reform providers. *American Educational Research Journal*, 44, 252-297.
- Rumelhart, D.E. 1980. Schemata: The building blocks of cognition. In R.J. Spiro, B. Bruce, & W.F. Brewer (Eds.). *Theoretical issues in reading and comprehension*. Hillsdale, NJ: Lawrence Erlbaum. pp. 33-58.
- Ryder, J., Banner, I., Homer, M. 2014. Teachers' experiences of science curriculum reform. *School Science Review*, 95 (352): 126-130.
- Sanders, L., Borko, H. & Lockard, J. 1993. Secondary science teachers' knowledge base when teaching science courses in and out of their area of certification. *Journal of Research in Science Teaching*, 30(7): 723-736.
- Sarason, S.B. 1990. *The predictable failure of educational reform: Can we change course before it's too late?* San Francisco: Jossey Bass.
- Schmidt, W. H., Hsing, C. W., & McKnight, C. C. 2005. Curriculum coherence: An examination of U.S. mathematics and science content standards from an international perspective. *Journal of Curriculum Studies*, 37(5), 525 – 559.

- Schutt, R.K. 2011. *Investigating the social world: The process and practice of research*, 7th ed. Thousand Oaks, CA: Sage Publications.
- Shenton, A.K. 2004. Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, 22: 63-75.
- Simon, M.K. 2011. *Dissertation and scholarly research: Recipes for success*. Seattle, WA: Dissertation Success, LLC.
- Silverman, D. 2001. *Interpreting qualitative data: Methods for analysing talk, text and interaction*, 2nd ed. London: Sage Publications.
- Smith, J.K. 1983. Quantitative versus qualitative research: An attempt to clarify the issue. *Educational Researcher*, 12: 6-13.
- Songer, N. B., & Gotwals, A. W. 2005. Fidelity of implementation in three sequential curricular units. In S. Lynch (Chair), "*Fidelity of implementation*" in *implementation and scale-up research designs: Applications from four studies of innovative science curriculum materials and diverse populations*. Symposium conducted at the meeting of the Annual Meeting of the American Educational Research Association. Montreal, Canada.
- Spiggle, S. 1994. Analysis and interpretation of qualitative data in consumer research. *Journal of Consumer Research*, 21(3): 491-503.
- Spillane, J.P. 2006. *Standards deviation: how schools misunderstood education policy*. London: Harvard University Press.
- Spillane, J.P. 1999. External reform initiatives and teachers' efforts to reconstruct their practice: The mediating role of teachers' zone of enactment. *Journal of Curriculum Studies*, 31(2): 143-175.
- Spillane, J.P., Reiser, B.J. & Reimer T. 2002. Policy implementation and cognition: Reframing and refocusing implementation research. *Review of Educational Research*, 72(3): 387-431.

- Stake, R.E. 2005. Qualitative case studies. In N.K. Denzin & Y.S. Lincoln (Eds.). *The Sage handbook of qualitative research*, 3rd ed.. Thousand Oaks, CA: Sage Publications. pp. 443-466.
- Stake, R.E. & Trumbull, D.J. 1982. Naturalistic generalizations. *Review Journal of Philosophy and Social Science*, 7: 3-12.
- Sternberg, R.J. & Horvath, J.A. 1995. A prototype view of expert teaching. *Educational Researcher*, 24(6): 9-17.
- Sternhouse, L. 1983. *An introduction to curriculum research and development*. London: Paul Chapman.
- Schwartz, M.S., Sadler, P.M., Sonnert, G. & Tai, R. H. 2008. Depth Versus Breadth: How Content Coverage in High School Science Courses Relates to Later Success in College Science Coursework; Wiley InterScience, www.interscience.wiley.com.
- Shulman, L. S. 1987. *Knowledge and teaching: foundations of the new reform*. Palo Alto, CA: Dale Seymour Publications.
- Strike, K.A., & Posner, G.J. 1992. A revisionist theory of conceptual change. In R. Duschl & R. Hamilton (eds.). *Philosophy of science, cognitive psychology, and educational theory and practice*. Albany, NY: SUNY Press. pp. 147-176.
- Talbert, J.E., McLaughlin, M.W. & Rowan, B. 1993. Understanding context effects on secondary school teaching. *Teachers College Record*, 95(1): 45-68
- Tashakkori, A. & Teddlie, C. 2010. Overview of contemporary issues in mixed-methods research. In A. Tashakkori & C. Teddlie (Eds.). *Handbook of mixed methods in social & behavioural research*. Thousand Oaks: Sage Publications. pp. 1-41.
- Taylor, D.L and Cameron A. 2016. Valuing IKS in successive South African Physical Sciences Curricula. *African Journal of Research in Mathematics, Science and Technology Education*, Vol. 20, No. 1, 35–44.

- Taylor, N., Muller, J. & Vinjevold, P. 2003. *Getting schools working: Research and systemic school reform in South Africa*. Cape Town: Pearson Education.
- Teddlie, C. & Tashakkori, A. 2009. *Foundations of mixed methods research: Integrating quantitative and qualitative techniques in the social and behavioral sciences*. Thousand Oaks, CA: Sage Publications.
- Terrell, S. 2011. *Mixed-methods research methodologies – The qualitative report*. Available at <http://www.nova.edu/ssss/QR/QR17-1/terrell.pdf> [Accessed 22 August 2015].
- Thompson, A.G. 1992. Teachers' beliefs and conceptions: A synthesis of the research. In D. Grouws (Ed.). *Handbook of research on mathematics teaching and learning*. Macmillan, New York. pp. 127-146.
- Tobin, K. 1990. Research on laboratory activities: In pursuit of better questions and answers to improve learning. *School Science and Mathematics*, 90, 403–418.
- Torres, E.M. 2007. Effect of a perturbation on the chemical equilibrium: Comparison with Le Chatelier's principle. *Journal of Chemical Education*, 84(3): 516-519.
- Treu, P., Olivier, M.A.J., Bean, P., & Van der Walt, J.L. 2010. A group of educator's stance on the implementation of South Africa's further education and training curriculum. *Teacher and Teacher Education*, 26(2), 343-350.
- Tshiredo, L.L. 2013. The impact of the curriculum change in the teaching and learning of science: A case study in under-resourced schools in Vhembe District. Unpublished Master's dissertation. Pretoria: University of South Africa.
- Thijs, A. & Van den Akker, J. 2009. *Curriculum in Development*. Amsterdam: Netherlands Institute for Curriculum Development (SLO).
- Turner, D. W., III 2010. Qualitative interview design: A practical guide for novice investigators. *The Qualitative Report*, 15(3), 754-760.
- UMALUSI. 2014. What is the CAPS package? Overview. Pretoria. UMALUSI

- van den Akker, J. J. H. 2003. Curriculum perspectives: an introduction. In J. J. H. van den Akker, W. Kuiper & U. Hameyer (Eds.). *Curriculum landscape and trends*. Dordrecht: Kluwer. pp. 1-10.
- van den Akker, J., Fasoglio, D. & Mulder, H. 2008. A curriculum perspective on plurilingual education. Enschede: Netherlands institute for curriculum development. Available at https://www.coe.int/t/dg4/linguistic/Source/Source2010_ForumGeneva/SLO_persp2010_EN.pdf [Accessed 14 August 2015].
- van Veen, K., & Slegers, P. 2009. Teachers' emotions in a context of reforms: To a deeper understanding of teachers and reforms. In P. A. Schutz & M. Zembylas (Eds.), *Advances in teacher emotion research: The impact on teachers' lives* (pp. 233–251). Dordrecht, The Netherlands: Springer.
- Vartuli, Sue, & Rohs, Jovanna 2009. Assurance of outcome evaluation: Curriculum fidelity. *Journal of Research in Childhood Education*, 23, 502–512. doi:[10.1080/02568540909594677](https://doi.org/10.1080/02568540909594677)
- van Teijlingen, E.R., Rennie, A.M., Hundley, V., Graham, W. 2001. The importance of conducting and reporting pilot studies: the example of the Scottish Births Survey. *Journal of Advanced Nursing*, 34: 289-295.
- Veer, R. & Valsiner, J. 1993. *Understanding Vygotsky*. Oxford, UK: Blackwell.
- von Glasersfeld, E. 1995. *Radical constructivism: A way of knowing and learning*. Washington, DC: Falmer.
- Waghid, Y. 2007. Teacher mobility: a loss to South African schools? *Perspectives in Education*, 25, 101–108.
- Wallace, J., & Loudon, W. 1998. Curriculum Change in Science: Riding the Waves of Reform. In B. J. Fraser & K. G. Tobin (Eds.), *International Handbook of Science Education*. Dordrecht, The Netherlands: Kluwer Academic Publishers. pp. 471-485.

- Wertsch, J.V. 1985. *Vygotsky and the Social Formation of Mind*. Cambridge: Cambridge University Press
- Wilson, S.M., Shulman, L.S. & Richert, A.E. 1987. 150 different ways of knowing: Representation of knowledge in teaching. In J. Calderhead (Ed.). *Exploring teachers' thinking*. London: Cassell. pp. 104-124.
- Winches, J. 2007. Teacher autonomy: A critical review of the research and concept beyond applied linguistics. *Ikala, Revista de Lenguaje y Cultura*, 12(8): 245-275.
- Wolmarans, N. & Smit, R., 2010. The impact of NSC mathematics on student performance in mathematics in first-year engineering programmes: Where does the gap lie?, 1-10.
- Woolfolk, A. 2001. *Educational Psychology*, 8th ed. Allyn and Bacon.

Appendices

Appendix A1

Ethical Clearance (UFSHSD2015/0632)



Faculty of Education

25-Nov-2015

Dear Mr Remeredzayi Gudyanga

Ethics Clearance: Physical Sciences teachers' perspectives and practices on the new Curriculum and Assessment Policy Statement (CAPS) in the Motheo District of South Africa

Principal Investigator: Mr Remeredzayi Gudyanga

Department: School of Education Studies (Bloemfontein Campus)

APPLICATION APPROVED

With reference to your application for ethical clearance with the Faculty of Education, I am pleased to inform you on behalf of the Ethics Board of the faculty that you have been granted ethical clearance for your research.

Your ethical clearance number, to be used in all correspondence is: **UFS-HSD2015/0632**

This ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the ethics office to ensure we are kept up to date with your progress and any ethical implications that may arise.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours faithfully



Dr. Juliet Romahai
Chairperson: Ethics Committee

Education Ethics Committee
Office of the Dean: Education
T: +27 (0)51 401 9683 | F: +27 (0)86 546 1113 | E: RamohaiJ@ufs.ac.za
Winkie Direko Building | P.O. Box/Posbus 339 | Bloemfontein 9300 | South Africa
www.ufs.ac.za



Note: The initial title in the early stages of the study was as on this page. However, as the study evolved the title was refined and registered as on the title page

Appendix A2

Permission from the Free State Department of Education

Enquiries: BM Kitching
Ref: Research Permission R Gudyanga
Tel. 051 404 9283 / 9221
Email: berthakitching@gmail.com and research@edu.fs.gov.za



R Gudyanga
54 Morgan Heath
22 Alexandra Avenue
Bloemfontein, 9301

Dear Mr Gudyanga

APPROVAL TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION

1. This letter serves as an acknowledgement of receipt of your request to conduct research in the Free State Department of Education.

Research Topic: Physical sciences teachers' perspectives, concerns and practices on the Curriculum and Assessment Policy Statement (CAPS) Implementation in the Motheo District of the Free State Province.

2. Approval is herewith granted to conduct research in the 82 schools offering Physical Sciences in Motheo District as indicated on the attached list.
3. **Target Population:** 110 Grade 10, 11 and 12 Physical Sciences Male and Female Teachers
4. **Period of research:** For three months from the date of signature of this letter. Please note the department does not allow any research to be conducted during the fourth term (quarter) of the academic year.
5. Should you fall behind your schedule by three months to complete your research project in the approved period, you will need to apply for an extension.
6. The approval is subject to the following conditions:
 - 6.1 The collection of data should not interfere with the normal tuition time or teaching process.
 - 6.2 A bound copy of the research document should be submitted to the Free State Department of Education, Room 319, 3rd Floor, Old CNA Building, Charlotte Maxeke Street, Bloemfontein.
 - 6.3 You will be expected, on completion of your research study to make a presentation to the relevant stakeholders in the Department.
 - 6.4 The attached ethics documents must be adhered to in the discourse of your study in our department.
7. Please note that costs relating to all the conditions mentioned above are your own responsibility.

Yours sincerely


DR JEM SEKOLANYANE
CHIEF FINANCIAL OFFICER

DATE: 25/01/2016

RESEARCH NDOBE PERMISSION GUDYANGA 18 JAN 2016

Strategic Planning, Policy & Research Directorate

Private Bag X20565, Bloemfontein, 9300 - Room 318, Old CNA Building, 3rd Floor, Charlotte Maxeke Street, Bloemfontein

Tel: (051) 404 9283 / 9221 Fax: (086) 6678 678

Note: The initial title in the early stages of the study was as on this page. However, as the study evolved the title was refined and registered as on the title page.

Appendix A3: Notification to Motheo District Office

Enquiries: BM Kitching
Ref: Notification of research:
Tel. 051 404 9221
Email: berthakitching@gmail.com and research@edu.fs.gov.za



The District Director
Motheo District

Dear Mr Tladi

NOTIFICATION OF A RESEARCH PROJECT IN YOUR DISTRICT BY R GUDYANGA

1. The abovementioned candidate was granted permission to conduct research in your district as follows:

Topic: Research Topic: Physical sciences teachers' perspectives, concerns and practices on the Curriculum and Assessment Policy Statement (CAPS) Implementation in the Motheo District of the Free State Province.

Schools involved: 82 Schools offering Physical Sciences in Motheo District as indicated on the attached list.

Target Population:

Period: Three months from the date of signature of this letter. Please note the department does not allow any research to be conducted during the fourth term / academic quarter of the year.

2. **Research benefits:** The research will inform policy makers and decision makers in the Department on what concerns Physical Science teachers are having during the implementation of CAPS to be used by departmental officials to develop strategies and formulate policy that would help remove some of the barriers for change confronting teachers and ultimately enhance the implementation process. The study also avails instruments that Departmental authorities may use to monitor curriculum implementation during times of education reforms.
3. Logistical procedures were met, in particular ethical considerations for conducting research in the Free State Department of Education.
4. The Strategic Planning, Policy and Research Directorate will make the necessary arrangements for the researcher to present the findings and recommendations to the relevant officials in your district.

Yours sincerely


DR JEM SEKOLANYANE
CFO

DATE: 25/01/2016

RESEARCH APPLICATION NOTIFICATION GUDYANGA MOTHEO 18 JAN 2016

Strategic Planning, Research & Policy Directorate

Private Bag X20565, Bloemfontein, 9300 - Old CNA Building, Room 318, 3rd Floor, Charlotte Mexeke Street, Bloemfontein

Tel: (051) 404 9283 / 9221 Fax: (086) 6678 678

Note: The initial title in the early stages of the study was as on this page. However, as the study evolved the title was refined and registered as on the title page.

Appendix B1: Principals: Request to conduct Research

Private Bag 7921

Kagisanong

Bloemfontein 9301

The Principal

XXXX Senior Secondary School

Bloemfontein 9301

Request for Permission to conduct a Research Study in your School

Dear Sir/Madam

I, Remeredzayi Gudyanga, hereby request permission to conduct a research study in your school. This research, which is part of my PhD studies with the University of the Free State, is entitled:

Physical sciences teachers' perspectives and practices on the new Curriculum and Assessment Policy Statement

This study has the potential to benefit teachers of Physical Science teachers in their implementation of the current CAPS policy. Furthermore, it will assist policymakers in assessing and evaluating the implementation process and may assist in developing the right intervention strategies to aid the reform process.

My interaction with the selected teachers will involve; 1) A survey questionnaire on about 150 grades 10, 11 and 12 physical sciences teachers; 2) An Interview of about 60 minutes on 10 selected teachers 3) Class observations of two lessons on 10 selected teachers; Classroom

observations will be arranged according to the respective teachers' time tables in ways that cause the least possible inconvenience to the school program.

Participation is entirely voluntary and teachers may withdraw from the study at any time should they wish to do so. I will observe confidentiality and protect participant from any harm, physical or psychological. The real names of the schools and the participants will not be used in any reports of the study. At completion of the study, I will provide the Department of Basic Education with a copy of the study report.

For further questions, information or suggestions please be free to contact me and/or my research supervisor Professor Loyiso C. Jita at Jitalc@ufs.ac.za or use the following telephone numbers: +27 (0)51 4017 522.

Thank you for considering this request.

.....

R. Gudyanga

Cell: 083 686 4991

E-mail: remegud@gmail.com

Appendix B2: Request for teacher Consent to participate in Research

Private Bag

Kagisanong 7921, Bloemfontein

Physical Science Teacher (Grade 10, 11 or 12)

XXXX Senior Secondary School

Bloemfontein 9301

INVITATION TO PARTICIPATE IN A RESEARCH STUDY

Dear Sir/Madam

My name is Remeredzayi Gudyanga, and I am currently studying towards a PhD degree with the University of the Free State. As part of my studies I am conducting a study entitled:

Physical sciences teachers' perspectives and practices on the new Curriculum and Assessment Policy Statement

The purpose of my study is to explore physical sciences teachers' perspectives and practices during the implementation of the CAPS.

You have been identified as one of the Grade 10, 11 or 12 physical sciences teachers who is currently involved in the implementation of CAPS and whose concerns, perspectives and practices would help respond to the sub-research questions in this study. This study has the potential to benefit you and other teachers as well as the broader Department of education and respective policy makers in South Africa.

Our interaction for this study will involve a survey questionnaire that will be filled online for about an hour. You may also be contacted for follow-up interviews and observations based on your responses to the survey. Each interview will last for no more than one hour, while observations will be arranged during the physical sciences double period at your school. Permission will be requested to use a recording device during the interviews.

Your participation is entirely voluntary and you may withdraw from the study at any time should you wish to do so. Whether you agree to take part or decline to take part will remain unknown to any third party. If you agree to take part in this important study, I will ensure to observe

confidentiality and to protect you or any other participant from any harm physical or psychological. The names of the schools and the participants will not be used in any reports of the study.

At completion of the study, I will provide the Department of Basic Education with a copy of the study report (without the names of the participants or the schools involved). The findings will also be shared with you and other Physical Science teachers.

Permission from the Department of Basic Education to carry out this study has already been granted.

For further information or any suggestions, please be free to contact me and/or my research supervisor Professor Loyiso C. Jita at Jitalc@ufs.ac.za or use the following telephone numbers: +27 (0)51 4017 522.

If you would like to participate in this study, please **give your consent** by signing and filling in your details at the bottom of this letter.

Thank you for considering this request.

.....

R. Gudyanga

Cell: 083 686 4991

E-mail: remegud@gmail.com

Name of Participant giving consent.....

Signature.....

Date.....

School.....

Cell Phone Number.....

Appendix C1 Copyright permission from SEDL to use Stages of Concern questionnaire



AIR LICENSE AGREEMENT

To: Remeredzayi Gudyanga (Licensee)
54 Morgan Heath
22 Alexandra Avenue
Bloemfontein, Free State
South Africa 9301

From: Nancy Reynolds
Senior Library Specialist
American Institutes for Research
Library—License Agreements
4700 Mueller Blvd.
Austin, TX 78723

Subject: License Agreement to reprint and distribute materials published by SEDL,
an Affiliate of American Institutes for Research

Date: November 17, 2015

Thank you for your interest in using the **Stages of Concern Questionnaire 075** published by SEDL in 2006 in *Measuring Implementation in Schools: The Stages of Concern Questionnaire* as Appendix A, pages 79-82, written by Archie A. George, Gene E. Hall, and Suzanne M. Stiegelbauer; in the book *Taking Charge of Change*, pages 48-49, written by Shirley M. Hord, William L. Rutherford, Leslie Huling-Austin, and Gene E. Hall, in 2006, with a 2nd printing in 2008, and a PDF version available at http://www.sedl.org/cbam/socq_manual_201410.pdf revised in 2014; and in electronic format as the *SoCQ Online* accessible at <http://www.sedl.org/pubs/catalog/items/cbam21.html>

This instrument will be referred to as the "work" in this AIR License Agreement. AIR is pleased to grant permission to the Licensee who use the work for a dissertation titled *Physical Sciences Teachers' Perspectives, Concerns, and Practices on the New Curriculum and Assessment Policy Statement (CAPS) in the Motheo District of South Africa* at University of Free State in Bloemfontein, South Africa. The following are the terms, conditions, and limitations governing this limited permission to reproduce the work:

1. All reproduction and distribution activities shall be in print format as SEDL's SoCQ 075 or as the online version created by SEDL as the *SoCQ Online* for educational, non-profit use only. Precise compliance with the following terms and conditions shall be required for any permitted reproduction of the work described above.
2. In using the SoCQ 075, the Licensee may substitute the words "the innovation" with a word or phrase that participants will recognize, such the name of the innovation or initiative, and questions can be added to identify demographic indicators or participants before or after the instrument, but otherwise, the wording and order of items cannot be changed.

4700 Mueller Blvd., Austin, TX 78723-3081 | 800.476.6861 | TTY 512.391.6578 | www.air.org

Note: In the early stages of the stud, the initial title was as on this page. However, as the study evolved the title was refined and registered as on the title page.

p. 2, AIR License Agreement

3. This permission is non-exclusive, non-transferable, and limited to the one-time use specified herein. This permission is granted solely for the period November 17, 2015 through December 31, 2016, inclusive. SEDL/AIR expressly reserves all rights in this material.
4. When you distribute copies of the work, you must give appropriate credit: "Reprinted by Remeredzayi Gudyanga with permission from SEDL, an Affiliate of American Institutes for Research" or attribute SEDL/AIR as appropriate to the professional style guidelines you are following. All reproductions of the materials used by you shall also bear the following copyright notice on each page of use: "Copyright ©2006 by SEDL, an Affiliate of American Institutes for Research."
5. This License Agreement to use the work is limited to the terms hereof and is personal to the person and entity to whom it has been granted; and it may not be assigned, given, or transferred to any other person or entity.
6. SEDL is not charging the Licensee a copyright fee to use the work.

I'm e-mailing you a PDF of this License Agreement. Please print and sign one copy below, indicating that you understand and agree to comply with the above terms, conditions and limitations, and send the original back to me. If you wish to keep a copy with original signatures, please print a second copy, and also sign and return it to me and, after I receive and sign it, I'll return it with both of our signatures to you.


Thank you, again, for your interest in using the **Stages of Concern Questionnaire 075**. If you have questions about AIR's License Agreement, please contact me at 800-476-6861, ext. 6548 or 512-391-6548, or by e-mail at nreynolds@air.org.

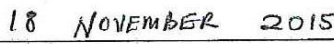
Sincerely,


Nancy Reynolds for American Institutes for Research


Date signed

Agreed and accepted:

Signature: 


Date signed

Printed Name: REMEREDZAYI GUDYANGA

0 1 2 3 4 5 6 7
 Irrelevant not true of me now Somewhat true of me now very true of me now

1	I am concerned about students' attitudes towards CAPS	0 1 2 3 4 5 6 7
2	I now know some other approaches that might work better	0 1 2 3 4 5 6 7
3	I am concerned about another change in syllabus	0 1 2 3 4 5 6 7
4	I am concerned about not having enough time to organise myself each day	0 1 2 3 4 5 6 7
5	I would like to help other teachers in the use of CAPS	0 1 2 3 4 5 6 7
6	I have little knowledge of CAPS	0 1 2 3 4 5 6 7
7	I would like to know the effect of reorganisation on my professional status	0 1 2 3 4 5 6 7
8	I am concerned about conflict between my interests and my responsibilities	0 1 2 3 4 5 6 7
9	I am concerned about revising my use of CAPS	0 1 2 3 4 5 6 7
10	I would like to develop working relationships with other teachers using CAPS	0 1 2 3 4 5 6 7
11	I am concerned about how caps affects learners	0 1 2 3 4 5 6 7
12	I am not concerned about CAPS at this time	0 1 2 3 4 5 6 7
13	I would like to know who makes the decisions in the new system	0 1 2 3 4 5 6 7

0 1 2 3 4 5 6 7
 Irrelevant not true of me now Somewhat true of me now very true of me now

14	I would like to discuss the possibility of using CAPS	0 1 2 3 4 5 6 7
15	I would like to know what resources are available for CAPS implementation	0 1 2 3 4 5 6 7
16	I am concerned about my inability to manage all that CAPS requires	0 1 2 3 4 5 6 7
17	I would like to know how my teaching or administration is supposed to change.	0 1 2 3 4 5 6 7
18	I would like to familiarise with other departments or persons with the progress of CAPS	0 1 2 3 4 5 6 7
19	I am concerned about evaluating my impact on learners	0 1 2 3 4 5 6 7
20	I would like to evaluate CAPS' approach	0 1 2 3 4 5 6 7
21	I am preoccupied with things other than CAPS	0 1 2 3 4 5 6 7
22	I would like to modify our use of CAPS based the experiences of our learners	0 1 2 3 4 5 6 7
23	I spend little time thinking about CAPS	0 1 2 3 4 5 6 7
24	I would like to excite my learners about their part in CAPS	0 1 2 3 4 5 6 7

0 1 2 3 4 5 6 7
 Irrelevant not true of me now Somewhat true of me now very true of me now

25	I am concerned about time spent working with non-academic problems related to CAPS	0 1 2 3 4 5 6 7
26	I would like to know what the use of CAPS would require in the immediate future	0 1 2 3 4 5 6 7
27	I would like to coordinate my efforts with others to maximise the effects of CAPS	0 1 2 3 4 5 6 7
28	I would like to have more information on time and energy commitments required by CAPS	0 1 2 3 4 5 6 7
29	I would like to know what other teachers are doing in this area	0 1 2 3 4 5 6 7
30	Currently, other priorities prevent me from focusing my attention on CAPS	0 1 2 3 4 5 6 7
31	I would like to determine how to supplement and enhance CAPS	0 1 2 3 4 5 6 7
32	I would like to use feedback from learners to improve the program	0 1 2 3 4 5 6 7
33	I would like to know how my role should change when I am using CAPS	0 1 2 3 4 5 6 7
34	Coordination of tasks and people is taking too much of my time	0 1 2 3 4 5 6 7
35	I would like to know how CAPS is better than NCS	0 1 2 3 4 5 6 7

Stages of concern questionnaire Section B

Demographic Data

Please use an X to indicate the option that most applies to you

1. How long have you been involved with CAPS, not counting this year?

.....4 Years

.....3 Years

.....2 Years

.....1 Year

.....0 Years

2. Years of Experience

.....More than 20 years

.....16-20 years

.....11-15 years

.....5-10 years

.....Under 5 years

3. Gender

.....Male Female

4. My teaching in physical sciences involves teaching.....

.....Both Chemistry and Physics topics

.....Physics topics only...

....Chemistry topics only

5. My Highest Level of Education earned.....

.....Certificate

.....Diploma

.....First Degree

.....Honours

.....Masters

.....PhD

6. My Major(s) are in

.....Physical sciences

.....Physics

.....Chemistry

.....None of the above

Stages of Concern Quick Scoring Device

A Date: May 6, 2006
 Site: 25 SS#: 6102
 Innovation: Unified Math

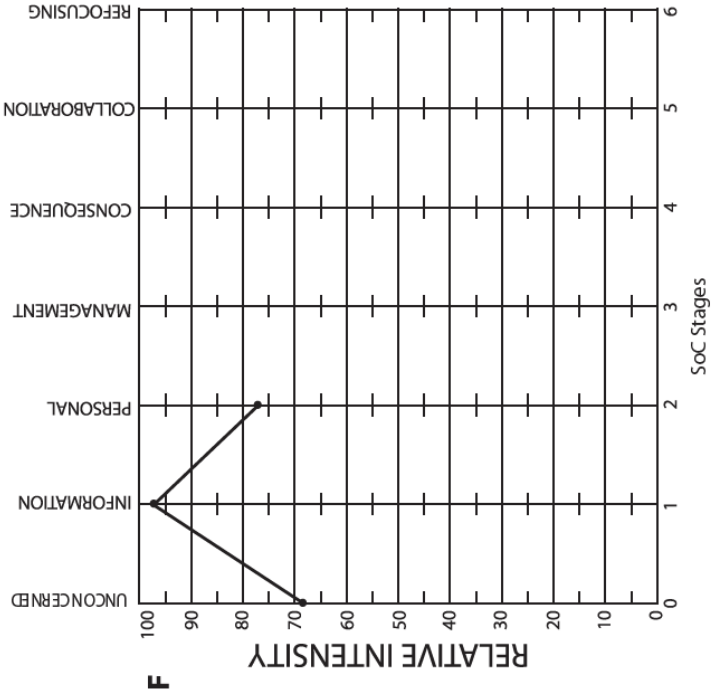
B

Stage	0	1	2	3	4	5	6
3	1	6	7	5	1	5	2
12	1	14	13	1	8	11	9
21	2	15	17	4	16	18	20
23	4	26	6	28	5	24	22
30	4	35	6	33	2	29	31

C Raw Score Totals 12
E Percentile Scores 69

D

Five-Item Raw Scale Score Total	Percentiles for:					
	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
0	0	5	5	2	1	1
1	1	12	12	5	1	2
2	2	16	14	7	1	3
3	4	19	17	9	2	3
4	7	23	21	11	2	4
5	14	27	25	15	3	5
6	22	30	28	18	3	7
7	31	34	31	23	4	9
8	40	37	35	27	5	10
9	48	40	39	30	5	12
10	55	43	41	34	7	14
11	61	45	45	39	8	16
12	69	48	48	43	9	19
13	75	51	52	47	11	22
14	81	54	55	52	13	25
15	87	57	57	56	16	28
16	91	60	59	60	19	31
17	94	63	63	65	21	36
18	96	66	67	69	24	40
19	97	69	70	73	27	44
20	98	72	72	77	30	48
21	99	75	76	80	33	52
22	99	80	78	83	38	55
23	99	84	80	85	43	59
24	99	88	83	88	48	64
25	99	90	85	90	54	68
26	99	91	87	92	59	72
27	99	93	89	94	63	76
28	99	95	91	95	66	80
29	99	96	92	97	71	84
30	99	97	94	97	76	88
31	99	98	95	98	82	91
32	99	99	96	98	86	95
33	99	99	96	99	90	95
34	99	99	97	99	92	97
35	99	99	99	99	96	99



Concerns Based Systems International

Appendix C4: Stages of concern percentile conversion chart

Figure 4.3. Stages of Concern Raw Score: Percentile Conversion Chart for the Stages of Concern Questionnaire

Raw Scale Score	Percentile Scores						
	0	1	2	3	4	5	6
0	0	5	5	2	1	1	1
1	1	12	12	5	1	2	2
2	2	16	14	7	1	3	3
3	4	19	17	9	2	3	5
4	7	23	21	11	2	4	6
5	14	27	25	15	3	5	9
6	22	30	28	18	3	7	11
7	31	34	31	23	4	9	14
8	40	37	35	27	5	10	17
9	48	40	39	30	5	12	20
10	55	43	41	34	7	14	22
11	61	45	45	39	8	16	26
12	69	48	48	43	9	19	30
13	75	51	52	47	11	22	34
14	81	54	55	52	13	25	38
15	87	57	57	56	16	28	42
16	91	60	59	60	19	31	47
17	94	63	63	65	21	36	52
18	96	66	67	69	24	40	57
19	97	69	70	73	27	44	60
20	98	72	72	77	30	48	65
21	99	75	76	80	33	52	69
22	99	80	78	83	38	55	73
23	99	84	80	85	43	59	77
24	99	88	83	88	48	64	81
25	99	90	85	90	54	68	84
26	99	91	87	92	59	72	87
27	99	93	89	94	63	76	90
28	99	95	91	95	66	80	92
29	99	96	92	97	71	84	94
30	99	97	94	97	76	88	96
31	99	98	95	98	82	91	97
32	99	99	96	98	86	93	98
33	99	99	96	99	90	95	99
34	99	99	97	99	92	97	99
35	99	99	99	99	96	98	99

Appendix D: Observation Protocol

I. Background Information

1. Name of Teacher (optional)...XXXXXXXXXX
2. Location of class (School, room).....
3. Years of Teaching.....5. Qualifications.....
6. Topic Observed..... 7. Grade
7. Observer.....10. Date of Observation.....

11. Start Time..... 12. End time.....

II. Contextual Background and Activities

In the space provided below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (space, seating arrangements, etc), and any relevant details about the learners (number, gender, ethnicity) and teacher that you think are important. Use diagrams if they seem appropriate.

Record here events which may help documenting the ratings

Time	Description of events

III. Lesson Design and Implementation

		Notes
1	The instructional strategies and activities respected learners' prior knowledge and the preconceptions inherent therein	
2	The lesson was designed to engage learners as members of a learning community	
3	In this lesson, learner exploration preceded formal presentation	
4	This lesson encouraged learners to seek and value alternative modes of investigation or of problem solving	
5	The focus and direction of the lesson was often determined by ideas origination learners	

IV. Content

Prepositional Knowledge

		Notes
6	The lesson involved fundamental concepts of the subject	
7	The lesson promoted strongly coherent conceptual understanding	
8	The teacher had solid grasp of the subject matter content inherent in the lesson	
9	Elements of abstraction (i.e., symbolic representation, theory building) were encouraged when it was important to do so.	
10	Connections with other content disciplines and/or real world phenomena were explored and valued	

Procedural Knowledge

		Notes
11	Learners used a variety of means (models, drawing, graphs, concrete materials, manipulatives, etc.) to represent phenomena	
12	Learners made predictions, estimations and/or hypotheses and devised means for testing them	
13	Learners were actively engaged in thought-provoking activity that often involved the critical assessment of procedures	
14	Learners were reflective about their learning	
15	Intellectual rigor, constructive criticism and the challenging of ideas were valued	

Continue recording salient events

Time	Description of events

V. **Classroom Culture**

Communicative interactions

		Notes
16	Learners were involved in the communication of their ideas to others using a variety of means and media	
17	The teacher's questions triggered divergent modes of thinking	
18	There was a high proportion of learner talk and a significant of it occurred between and among learners	
19	Learner questions and comments often determined the focus and direction of classroom discourse	
20	There was climate of respect for what others had to say.	

Learner/Teacher Relationships

		Notes
21	Active participation of learners was encouraged and valued	
22	Learners were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence	
23	In general, the teacher was patient with learners	
24	The teacher acted as a resource person, working to support and enhance learner investigations	
25	The metaphor "teacher as listener" was very characteristic of this classroom	

Appendix E: Document Analysis Protocol/Schedule

The analysis of documents was informed by the following broad question:

How do physical sciences teachers transform the curriculum documents into their classroom practices?

The following will be analysed:

1. What official documents do physical sciences teachers use to prepare for their class lessons?
2. What other support documents do physical sciences teachers use?
3. What sources do teachers use for their subject content knowledge?
4. Are there any other relevant aspects in their files that assist them in making sense of the CAPS curriculum?

Appendix F: Semi-structured interview

General outline of interview.

1. Opening

- a. (Introductions and establishing rapport) Hello Mr./Ms. xxxxx. My name is Remeredzayi Gudyanga. I am a PhD student at the University of the Free State. I appreciate that you agreed to have an interview with me. Thank you so much, you are appreciated. I have a small device that will be recording our interview. If I may just turn it on. Thank you.
- b. (Purpose of the interview) I would like to learn from you about your perspectives in regards to the new Curriculum- the CAPS.
- c. (Motivation) The information will help me in the study I am conducting on perspectives that physical sciences teachers have in regards to the changes brought about by CAPS.
- d. (Duration) The interview should take about an hour.

2. Body

A. (Background information)

- a. For how long have you been teaching?
- b. For how long have you been teaching physical sciences Grades 10, 11 and/or 12 before the introduction of CAPS?
- c. Before the change to CAPS did you in any way felt there was a need to change some things in the NCS? If yes can you elaborate?
- d. What kind of assistance through workshops or otherwise were made available to you in preparation for CAPS implementation?
- e. How do you feel about the assistance provided? Do you feel it was adequate? Elaborate.

B. Current experiences

- i. What do you consider to be the biggest difference between NCS and CAPS in the physical sciences?
- ii. How has the change from NCS to CAPS impacted on your practices in the classroom?
- iii. What do you find positive about the change from NCS to CAPS?

- iv. What do you find negative about the change from NCS to CAPS?
- v. What are the current challenges that you face that make it difficult to implement CAPS?
- vi. Can you say your job has been made easier by the change from NCS to CAPS? Please elaborate.
- vii. What kind of assistance would you need so that you can better implement CAPS?

3. Conclusions

- a. (Summarise) I understand that you (try summarising their perspectives, about CAPS)
- b. (Thanking them) I appreciate the time you have spared and the information I got from this interview will be very useful for my study. Do you have anything else to say that may help me understand better some of the aspects we have been talking about?
- c. (Farewell and maintaining possible future contact) Once more I thank you very much for your time. I have the information I need for now, I think. However, would you mind if I come back again in case I feel I need to talk to you about the study again?

Appendix G: *Grade 11 work schedule term 3

TOPICS	Week	Date completed	Assignments (Homework / Class work)	Practical investigations/ Experiments	Informal tests	
9. ELECTRICITY & MAGNETISM: Electrostatics <ul style="list-style-type: none"> Coulomb's Law: $F = \frac{kQ_1Q_2}{r^2}$ Force exerted on a charge by one or more charges in one dimension (1D) and two dimensions (2D). Electric field and its direction. Electric field patterns for various configurations of charges. 	1		56		7	
			57			
			58			
			59			
<ul style="list-style-type: none"> Magnitude of the electric field at a point as the force per unit charge: $E = \frac{F}{q}$ (E and F are vectors). Calculate the electric field at a point: $E = \frac{kQ}{r^2}$ 	2		60			
			61			
			62			
10. ELECTRICITY & MAGNETISM: Electromagnetism <ul style="list-style-type: none"> Magnetic field associated with current carrying wires. Use the Right Hand Rule to determine the magnetic field associated with a straight current carrying wire, a current carrying loop (single) of wire & a solenoid. Magnetic field lines around a straight current carrying wire, a current carrying loop (single) of wire & a solenoid. Environmental impact of overhead electrical cables. 	3		63			P11: Induced current in a coil by moving a magnet in and out of the coil (demonstration)
			64			
			65			
			66			
<ul style="list-style-type: none"> Right Hand Rule: Direction of induced current in a solenoid when the N or S pole of a magnet is inserted or pulled out. Magnetic flux (Φ) passing through a loop: $\Phi = BA\cos\theta$ Faraday's Law: $\epsilon = -N \frac{\Delta\Phi}{\Delta t}$ 	4		67			
			68			
			69			
11. ELECTRICITY & MAGNETISM: Electric circuits <ul style="list-style-type: none"> Relationship between current, voltage and resistance at constant temperature. Ohmic and non-ohmic conductors. Ohm's law, $R = \frac{V}{I}$, for series and parallel circuits. 	5		70	P12: Ohm's law	9	
			71			
			72			
			73			
<ul style="list-style-type: none"> Power measured in watt (W). Electrical power dissipated in a device: $P = VI$, $P=I^2R$, $P = \frac{V^2}{R}$ Electrical energy: $E = Pt$ measured in joule (J) Kilowatt hour (kWh) & cost of electricity. 	6		74			
			75			
			76			
12. CHEMICAL CHANGE: Energy & chemical change <ul style="list-style-type: none"> Enthalpy and its relationship to heat of reaction. Exothermic and endothermic reactions. Potential energy graphs for exothermic and endothermic reactions with and without catalysts. Activation energy. 	7		77			P13: Exothermic and endothermic reactions
			78			
			79			
			80			
13. CHEMICAL CHANGE: Types of reaction <ul style="list-style-type: none"> Arrhenius & Bronsted-Lowrey theory for acids and bases. Identify conjugate acid/base pairs, ampholytes. Common acids & bases & indicators. Equations for acid-metal hydroxide, acid- metal oxide & acid - metal carbonate reactions to produce salts. Indicators. 	8		81	P14: Acid-base titration		
	& 9		82			
			83			
			84			
Control Test 2 (September examination)	10 & 11					

*(Extracted from the Free State Department of Education 2015)

Appendix H: *Grade 12 Work schedule second term

TOPICS	Week	Date completed	Assignments (Homework / Class work)	Practical investigations/ Experiments	Informal tests
4. MECHANICS: Work, energy and power <ul style="list-style-type: none"> Define the work done on an object; Draw force diagram & free-body diagrams. Calculate the net work done on an object. Distinguish between positive work and negative net work done on the system. Define the work-energy theorem. Apply the work-energy theorem on horizontal, vertical and inclined planes. Define conservative and non-conservative forces and give examples. State the principle of conservation of mechanical energy. 	1		31		5
			32		
	&	2	33		
			34		
			35		
		3	36		
			37		
38					
5. WAVES, SOUND & LIGHT: Doppler Effect <ul style="list-style-type: none"> Solve problems using the equation: $W_{nc} = \Delta E_k + \Delta E_p$ Show that E_{mech} is conserved in absence of non-conservative forces. Define power and calculate the power involved when work is done. Perform calculations using $P_{ave} = Fv_{ave}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane. Calculate the minimum power required of an electric motor to pump water from a borehole of a particular depth at a particular rate using $W_{nc} = \Delta E_k + \Delta E_p$. 	4		39		6
			40		
			41		
			42		
6. CHEMICAL CHANGE: Rate and extent of reaction <ul style="list-style-type: none"> State the Doppler effect and explain (using illustrations) the change in pitch observed when a source moves toward or away from a listener (sound and ultra sound). State applications of the Doppler effect. Solve problems using $f_L = \frac{v \pm v_L}{v \pm v_S} f_s$ when EITHER source or listener moves. With light, explain 'red shifts' & use the Doppler Effect to explain why we conclude that the universe is expanding. 	5		43	Informal exp. 1: The effect of temperature and concentration on the rate of the reaction between $Na_2S_2O_3$ and HCl	7
			44		
			45		
			46		
7. CHEMICAL CHANGE: Chemical equilibrium <ul style="list-style-type: none"> Explain: open & closed systems; reversible reactions; dynamic equilibrium List the factors which influence the position of an equilibrium. State Le Chatelier's principle and use it to explain changes in equilibria. Interpret simple graphs of equilibrium. Explain the use of rate & equilibrium principles in the Haber & Contact process. 	6		47	Informal exp. 2: Demonstrate factors that influence the equilibrium of $CoCl_2$ & H_2O	8
			48		
			49		
<ul style="list-style-type: none"> List the factors which influence the value of the equilibrium constant K_c. Write an expression for the equilibrium constant from a given equation. Perform calculations based on K_c values and Explain the significance of high and low values of the equilibrium constant. 	7		50		9
			51		
			52		
			53		
8. CHEMICAL CHANGE: Acids and bases <ul style="list-style-type: none"> Define acids and bases according to Arrhenius and Lowry-Brønsted. Distinguish between strong and weak acids/bases with examples. Distinguish between concentrated and dilute acids/bases. Identify conjugate acid-base pairs for given compounds. Write neutralisation reactions of common laboratory acids and bases. Perform calculations based on titration reactions & motivate choice of indicator. 	8		54	Formal exp. 3: Titration of oxalic acid against NaOH to determine the concentration of NaOH	9
			55		
			56		
			57		
<ul style="list-style-type: none"> Determine the approximate pH of salts in salt hydrolysis. Explain the pH scale and calculate pH values of strong acids and strong bases. Define the concept of K_w and explain the auto-ionisation of water. Compare the K_a and K_b values of strong and weak acids and bases. Compare strong and weak acids by looking at pH, conductivity & reaction rate. 	9		58		10
			59		
			60		
			61		
June examination Test: Experiment 3	10 & 11				

*(Extracted from the Free State Department of Education 2015)

Appendix I: Examinable Content Grade 12 on Acids and Bases

(Extracted from University of the Free State Schools Partnership Programme, 2015)

Define acids and bases according to Arrhenius and Lowry-Brønsted:

Arrhenius theory: An acid is a substance that produces hydrogen ions (H^+)/hydronium ions (H_3O^+) when it dissolves in water. A base is a substance that produces hydroxide ions (OH^-) when it dissolves in water.

Lowry-Brønsted theory: An acid is a proton (H^+ ion) donor. A base is a proton (H^+ ion) acceptor.

Distinguish between strong acids/bases and weak acids/bases with examples.

Strong acids ionise completely in water to form a high concentration of H_3O^+ ions. Examples of strong acids are hydrochloric acid, sulphuric acid and nitric acid.

Weak acids ionise incompletely in water to form a low concentration of H_3O^+ ions. Examples of weak acids are ethanoic acid and oxalic acid.

Strong bases dissociate completely in water to form a high concentration of OH^- ions. Examples of strong bases are sodium hydroxide and potassium hydroxide.

Weak bases dissociate/ionise incompletely in water to form a low concentration of OH^- ions.

Examples of weak bases are ammonia, calcium carbonate, potassium carbonate, calcium carbonate and sodium hydrogen carbonate.

Distinguish between concentrated acids/bases and dilute acids/bases.

Concentrated acids/bases contain a large amount (number of moles) of acid/base in proportion to the volume of water.

Dilute acids/bases contain a small amount (number of moles) of acid/base in proportion to the volume of water.

Write down the reaction equations of aqueous solutions of acids and bases.

Examples: $\text{HCl}(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{Cl}^-(\text{aq})$ (HCl is a monoprotic acid.)

$\text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$ □4

$\text{H}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{H}_3\text{O}^+(\text{aq}) + (\text{aq}) \text{SO}_4^{2-}$ (H_2SO_4 is a diprotic acid.)

Identify conjugate acid-base pairs for given compounds. When the acid, HA , loses a proton, its conjugate base, A^- , is formed. When the base, A^- accepts a proton, its conjugate acid, HA , is formed. These two are a conjugate acid-base pair.

Appendix I: Examinable Content Grade 12 on Acids and Bases (continued)

(Extracted from University of the Free State Schools Partnership Programme)

Describe a substance that can act as either acid or base as amphiprotic or as an ampholyte. Water is a good example of an ampholyte. Write equations to show how an amphiprotic substance can act as acid or base.

Write down neutralisation reactions of common laboratory acids and bases.

Acid-base reactions

Examples: $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq})/\text{KOH}(\text{aq}) \rightarrow \text{NaCl}(\text{aq})/\text{KCl}(\text{aq}) + \text{H}_2\text{O}(\ell)$

$\text{HCl}(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\ell) + \text{CO}_2(\text{g})$

$\text{HNO}_3(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaNO}_3(\text{aq}) + \text{H}_2\text{O}(\ell)$

$\text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\ell)$

$(\text{COOH})_2(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow (\text{COO})_2\text{Na}_2(\text{aq}) + \text{H}_2\text{O}(\ell)$

$\text{CH}_3\text{COOH}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{CH}_3\text{COONa}(\text{aq}) + \text{H}_2\text{O}(\ell)$

NOTE: The above are examples of equations that candidates should be able to write from given information. However, any other neutralisation reaction can be given in the question paper to assess, e.g., stoichiometry calculations.

Determine the approximate pH (equal to, smaller than or larger than 7) of salts in salt hydrolysis. Define *hydrolysis* as the reaction of a salt with water.

o Hydrolysis of the salt of a weak acid and a strong base result in an alkaline solution, i.e. the $\text{pH} > 7$. Examples of such salts are sodium ethanoate, sodium oxalate and sodium carbonate.

o Hydrolysis of the salt of a strong acid and a weak base result in an acidic solution, i.e. the $\text{pH} < 7$. An example of such a salt is ammonium chloride.

o The salt of a strong acid and a strong bases does not undergo hydrolysis and the solution of the salt will be neutral, i.e. $\text{pH} = 7$.

Motivate the choice of a specific indicator in a titration. Choose from methyl orange, phenolphthalein and bromothymol blue. Define the *equivalence point* of a titration as the point at which the acid /base has completely reacted with the base/acid.

Define the *endpoint* of a titration as the point where the indicator changes colour.

Perform stoichiometric calculations based on titrations of a strong acid with a strong base, a strong acid with a weak base and a weak acid with a strong base. Calculations may include percentage purity.

Appendix I: Examinable Content Grade 12 on Acids and Bases (continued)

(Extracted from University of the Free State Schools Partnership Programme, 2015)

For a titration, e.g. the titration of oxalic acid with sodium hydroxide:

List the apparatus needed or identify the apparatus from a diagram.

Describe the procedure to prepare a standard oxalic acid solution.

Describe the procedure to conduct the titration.

Describe safety precautions.

Describe measures that need to be in place to ensure reliable results.

Interpret given results to determine the unknown concentration.

Explain the pH scale as a scale of numbers from 0 to 14 used to express the acidity or alkalinity of a solution.

Calculate pH values of strong acids and strong bases using $\text{pH} = -\log [\text{H}_3\text{O}^+]$.

Define K_w as the equilibrium constant for the ionisation of water or the ionic product of water or the ionisation constant of water, i.e. $K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$ by 298 K.

Explain the *auto-ionisation of water*, i.e. the reaction of water with itself to form H_3O^+ ions and OH^- ions.

Interpret K_a values of acids to determine the relative strength of given acids. Interpret K_b values of bases to determine the relative strength of given bases.

Compare strong and weak acids by looking at:

- ✓ pH (monoprotic and diprotic acids)
- ✓ Conductivity
- ✓ Reaction rate

Appendix: J: Andres Practical class: Titration

(Extracted from University of the Free State Schools Partnership Programme, 2015)

Surname.....Name.....
...Grade.....

Experiment : Acid-base titration: Titration of oxalic acid against sodium hydroxide to determine the concentration of a sodium hydroxide solution

Aim

To determine the concentration of a supplied sodium hydroxide solution using a standard solution of oxalic acid.

Investigative question

Formulate investigative question for this investigation. [2]

Hypothesis

Formulate a hypothesis for this investigation. [2]

Apparatus and chemicals

1. 100ml Volumetric flask.
2. Mass meter.
3. 25 ml Burette.
4. 25 ml Pipette.
5. 2 x Erlenmeyer flasks.
6. Beaker.

Appendix: J: Andres Practical class: Titration (Continued)

(Extracted from University of the Free State Schools Partnership Programme, 2015)

7. Filter funnel.
8. Wash bottle.
9. Retort stand, bosshead and clamp.
10. Oxalic acid.
11. Sodium hydroxide solution (unknown concentration +/- 0,2 M)
12. Phenolphthalein indicator.
13. Spatula.
14. Medicine dropper.
15. Filter paper.

Safety precautions

The acid, base and indicator should not come into contact with the skin or eyes. Immediately flush contaminated area with water. Safety goggles are recommended.

Method

A: Preparing a standard solution of oxalic acid

1. Calculate the formula mass of oxalic acid $(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$. [1]

2. What mass do you require to make 1 litre of 0,1 M solution of oxalic acid?
(Remember to take into account the $2\text{H}_2\text{O}$). [3]

3. What mass do you require to make 100 ml of 0,1 M solution of oxalic acid? [1]

4. Measure out this mass of oxalic acid accurately to one decimal place, using a small sheet of folded filter paper. **Tare the balance to correct for the mass of the paper.**
5. Carefully pour the measured amount of oxalic acid into the 100 ml volumetric flask.

Appendix J: Andres Practical class: Titration (Continued)

6. Add some water to the volumetric flask until it is half full. Close the flask with a stopper and shake the contents to dissolve the oxalic acid. Continue adding water with the wash bottle, **very slowly at the end**, until the bottom of the meniscus of the liquid just lines up with the marker on the stem of the flask. Replace the stopper and give a final shake to ensure even mixing. Label the flask.
7. This is your standard solution.

B: Finding the concentration of a solution to the zero mark of sodium hydroxide by titrating it against a standard solution of oxalic acid

1. Fit the burette into the clamp on the retort stand. Use the funnel to pour the sodium hydroxide solution into the burette.
2. Place a beaker under the tap of the burette and open the tap just long enough to expel the air in the bottom tube. Fill the burette to the zero mark.
3. Pipette 25 ml of the standard oxalic acid solution into the Erlenmeyer flask.
4. Add 2 drops of phenolphthalein to the flask and swirl it gently to distribute the indicator.
5. Place the flask under the tap of the burette. Place a white tile or else a sheet of white paper underneath the flask to improve visibility of any colour change during titration.
6. Slowly run in the sodium hydroxide solution from the burette, controlling the tap with your left hand while swirling the flask with your right hand. If some of the sodium hydroxide solution is spilled onto the sides of the flask, use the wash bottle to wash it into the solution.
7. When you get near the end point, add the solution from the burette drop by drop, until the solution turns a pale pink and holds this colour for approximately 10 – 15 seconds.
8. Close the tap and record the volume of sodium hydroxide used in the table below.
9. Refill the burette to the zero mark and repeat this procedure two more times so that you have three readings. Take the average of these readings to see how much sodium hydroxide is needed to neutralize 25 ml of oxalic acid.

Appendix: J: Andres Practical class: Titration (Continued)

(Extracted from University of the Free State Schools Partnership Programme, 2015)

Results

Titration	Volume of oxalic acid in ml	Volume of sodium hydroxide in ml
1	25	
2	25	
3	25	
Average	25	

[4]

Interpretation of results

1. Write down a balanced equation for the reaction between oxalic acid and sodium hydroxide. [3]

—

2. How many moles of sodium hydroxide will react with one mole of oxalic acid? [1]

—

3. Calculate the number of moles of oxalic acid in the Erlenmeyer flask. [3]

4. Calculate the number of moles of sodium hydroxide needed to neutralise the oxalic acid in the Erlenmeyer flask. [3]

5. Calculate the concentration of the sodium hydroxide solution. [3]

Appendix: J: Andres Practical class: Titration (Continued)

(Extracted from University of the Free State Schools Partnership Programme, 2015)

6. How does the experimentally determined concentration of sodium hydroxide compare to the estimated value of $0,2 \text{ mol}\cdot\text{dm}^{-3}$? [1]

7. List factors that could give rise to experimental error. [4]

Conclusion [2]

Formulate a conclusion for this investigation.

Total marks = 33

(If sodium hydroxide solution is not supplied, the following procedure can be followed to prepare a solution with a molarity of $\pm 0,2 \text{ mol}\cdot\text{dm}^{-3}$:

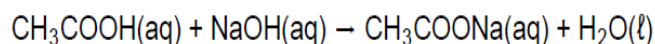
1. Place a small sheet of folded filter paper on the mass meter and tare the mass meter to compensate for the mass of the paper. Measure around $0,8 - 0,9 \text{ g}$ NaOH using the mass meter.
2. Dissolve the NaOH in 100 ml of water in a beaker.)

Appendix K: Karabo's Homework Question

(Department of Education Documents, 2014)

QUESTION 7 (Start on a new page.)

A Grade 12 class wants to determine the percentage of ethanoic acid in a certain bottle of vinegar. They titrate a sample taken from the bottle of vinegar with a standard solution of sodium hydroxide. The equation for the reaction is:



7.1 Define an *acid* in terms of the Arrhenius theory. (2)

7.2 Give a reason why ethanoic acid is classified as a weak acid. (1)

7.3 Explain the meaning of *standard solution*. (1)

7.4 Write down the names of TWO items of apparatus needed to measure accurate volumes of the acid and the base in this titration. (2)

7.5 It is found that 40 ml of a 0,5 mol·dm⁻³ sodium hydroxide solution is needed to neutralise 20 ml of the vinegar.

Calculate the:

7.5.1 pH of the sodium hydroxide solution (4)

7.5.2 Percentage of ethanoic acid by mass present in the vinegar
(Assume that 1 ml of vinegar has a mass of 1 g.) (7)

7.6 The sodium ethanoate (CH₃COONa) formed during the above neutralisation reaction undergoes hydrolysis to form an alkaline solution. Write down an equation for this hydrolysis reaction. (3)

[20]

Appendix L: Karabo's Classwork Question

(Extracted from the Free State Department of Education, 2015)

Physical Sciences P2
PREPARATORY EXAMINATION

12

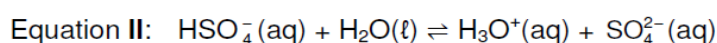
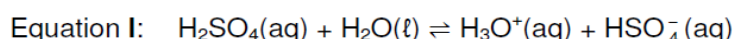
FS September 2014

QUESTION 7 (Start on a new page.)

7.1 Sulphuric acid is a strong acid and an example of an acid which can donate two protons per molecule.

7.1.1 Write down one word or term for the underlined phrase. (1)

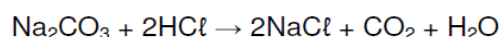
The equations below represent the ionisation of sulphuric acid.



7.1.2 Write down the FORMULA of a species that acts as ampholyte in the above reactions. (1)

7.1.3 Write down the NAME of the conjugate base of the hydrogen sulphate ion. (1)

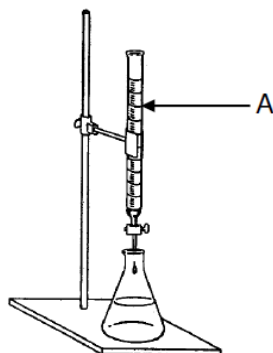
7.2 A learner adds an impure sample of sodium carbonate into a flask containing 50 cm^3 of a hydrochloric acid solution with a $\text{pH} = 0$. The hydrochloric acid is in excess. The balanced equation for the reaction that takes place is:



7.2.1 Calculate the number of moles of hydrochloric acid present in the flask. (5)

7.2.2 Write down a balanced equation that explains why a sodium carbonate solution has a pH greater than 7. (3)

7.2.3 The apparatus illustrated below is used during a titration to determine the mass of sodium carbonate present in the sample.



Write down the name of the apparatus labelled **A**. (1)

7.2.4 During the titration, the excess hydrochloric acid is neutralised by 30 cm^3 of a $0,4 \text{ mol}\cdot\text{dm}^{-3}$ sodium hydroxide solution. Calculate the mass of sodium carbonate in the sample. (6)

[18]

(Extracted from the Free State Education Departmental Documents, 2015)

Appendix M: Karabo's Practical class esterification

(Extracted from University of the Free State Schools Partnership Programme, 2015)

Surname: Name: Grade: Date:

Experiment 2: Preparation of esters

Apparatus

1. Test tubes and test tube holder
2. Ethanol
3. Mini pipettes
4. Beaker or cup with boiling water
5. Test tube rack
6. Concentrated sulphuric acid
7. Pentanol
8. Ethanoic acid

Method

Part 1:

1. Place a clean dry test tube in the test tube rack.
2. Use a mini pipette to add about 1 ml of ethanoic acid to test tube.
3. With a clean mini pipette then add about 1 ml of ethanol to the same test tube.
4. Shake the test tube gently to mix the contents.
5. Smell the mixture by wafting your hand over the mouth of the test tube to bring the smell to you. **N.B. DO NOT SMELL CHEMICALS BY SNIFFING ON THE TEST TUBE OR CONTAINER!** Write down what you smell.
6. Hold the test tube at an angle. Using a mini pipette, carefully add about 5 drops of concentrated sulphuric acid, drop by drop, to the mixture in the test tube. **BE VERY CAREFUL WHEN WORKING WITH CONCENTRATED SULPHURIC ACID – AND DO NOT TOUCH IT!**
7. **Place the empty pipette you have used in an empty, dry test tube for use later. Do not put it on the desk.**
8. Gently shake the test tube containing the alcohol, carboxylic acid and sulphuric acid to mix the contents.
9. Boil some water in a kettle or over a burner half fill a beaker or cup with the hot water.

10. Stand the test tube in the hot water for a few minutes.
11. Smell the product in the test tube by wafting the vapours to your nose. Write down what you smell.

Part 2:

12. Repeat the above experiment but this time use **pentanol** as the alcohol (use clean dry test tubes).

Results

Part 1:

Reactants and products	Odour
Ethanol	
Ethanoic acid	
Ethyl ethanoate	

[3]

Part 2:

Reactants and products	Odour
Pentanol	
Ethanoic acid	
Pentyl ethanoate	

[3]

Interpretation of results

1. Write down a general equation of the reaction that takes place between an alcohol and a carboxylic acid. [6]
2. How is the water formed in the reaction above? [2]
3. Write down the balanced chemical equations of the two reactions that took place. [8]
4. What safety precautions did you take during this experiment? [3]
5. What is the function of the sulphuric acid (H₂SO₄) used in the reaction? [1]

Conclusion

Write down a conclusion for the investigation. [2]

Total marks = 32