The relationship between teacher characteristics, classroom practices and learner achievement in Physical Science

by

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DEDICATION

A special note of thanks to my husband, Fritz, and son, Vincent for being so supportive and understanding. To my parents for always encouraging me. To Dr Vanessa Scherman for her countless hours of company and guidance. To Auntie Vimbai for loving my baby boy while I was working. To Cilla Douws for her fabulous vocabulary and editing skills and to Henri Labuschagne for the technical editing and SPSS wisdom. To the University of Pretoria, GDE and CEA for the use of the primary data and to all of the participants, thank you.

ABSTRACT

South Africa has a unique cultural, historical, socio-economic and linguistic contextual complexity that influences the implementation the intended curriculum and educational policies. The contextual complexity continues to result in Science teachers entering into the teaching profession with a wide spread diversity in background and qualifications. The secondary data analysis used a concurrent mixed methods approach (QUAL + quan) to explore the interconnection between teacher characteristics, classroom practices and learner achievement in Physical Science. The primary sample consisted of 18 schools that were stratified by district and quintile. From the available data, nineteen Grade 12 Physical Science teachers with varying levels of qualifications and experience were analysed. A combination of qualitative and quantitative instruments, specifically, Science teacher questionnaires, Science lesson observations and Science teacher interviews, were explored. The data was analysed quantitatively using descriptive statistics, frequency tables and Pearson correlation coefficients. The qualitative data involved content analysis and the presentation of case studies and the themes that emerged. Significant Pearson correlations indicate a positive relationship between years of related experience and pass rates and also pointed to an interconnection between professional qualifications, related experience and learner achievement. Differences in teacher characteristics were also indicators of competency in content knowledge and ultimately influenced classroom practices. Four case studies are offered in an attempt to provide in-depth descriptions of the teacher characteristics and practices for Grade 12 Physical Science teachers in Gauteng. Recommendations for future research, teacher training and policy implementation are presented. The diversity in teacher characteristics, particularly in Physical Science classrooms, influences the classroom practices that teachers select in their day-to-day teaching and impacts learner outcomes in terms of achievement.

KEY TERMS

Mixed Methods; Physical Science; Assessment; Teacher Characteristics; Teacher Qualifications; Experience; Subject Content Knowledge; Pedagogical Content Knowledge; Classroom Practices; Learner Achievement

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LIST OF ACRONYMS

ACE	Advanced Certificate in Education
CEA	Centre for Evaluation and Assessment
DoE	Department of Education (changed to Department of Basic Education (DBE))
FET	Further Education and Training
GDE	Gauteng Department of Education
HED	Higher Education Diploma
IEA	International Association for the Evaluation of Educational Achievement
INSET	In-service Education and Training
OBE	Outcomes Based Education
NBT	National Benchmark Test
NCS	National Curriculum Statement
PCK	Pedagogical Content Knowledge
PGCE	Postgraduate Certificate of Education
PRESET	Pre-service Education and Training
SACE	South African Council of Education
SAQA	South African Qualifications Authority
SBL	School-based Learning
SCK	Subject Content Knowledge
STEM	Science, Technology, Engineering and Mathematics
UBL	University-based Learning

CHAPTER 1
INTRODUCTION TO THE STUDY

1.1 INTRODUCTION

Internationally, a plethora of recent literature emphasizes an increasing concern for enhancing education in the areas of Mathematics and Science. According to the World Science Forum in 2007, "there is a direct correlation between a nation's wealth and its scientific and technological capacity" (James & Benson, 2008, p.2). This interest has arisen as a result of globalisation and the need for societies to become more competitive in the global market (Abrahams & Millar, 2008; James & Benson, 2008; Anderson, Lin, Treagust, Ross & Yore, 2007; Department of Education, 2005). For that reason, South Africa needs to increase the amount of people entering into professions that are related to Science and Technology in order to be more globally competitive. This competitive edge calls for Science teachers to put more emphasis on the quality implementation of Science, Technology, Engineering and Mathematics (STEM) subjects and to encourage learners to choose STEM careers. In order for this to be realised in South Africa, the level of Physical Science instruction must increase at a Further Education and Training (FET) level in order to ensure that the learners leaving Grade 12 are adequately prepared. According to literature, FET learners are fundamentally underprepared for University level Science (Jita & Ndalane, 2009; Potgieter, Davidowitz & Mathabatha, 2008; Gopal & Stears, 2007) and this can be attributed in part to the fact that South Africa has a shortage of well-qualified Science educators (Onwu & Stoffels, 2005; Onwu, 2000). The purpose of this research is to investigate the interconnection between teacher qualifications, classroom practices and learner achievement for Grade 12 Physical Science in a variety of Gauteng secondary schools.

A general introduction to the key definitions that are pivotal for this research study are provided in Section 1.2; specifically, concept clarification for teacher characteristics, classroom practices, and learner achievement. Secondly, a background to the study with regards to the context of the primary research project is exemplified in Section 1.3. Subsequently, Section 1.4 discusses the problem statement and Section 1.5 presents the rationale behind the study. Following this, the objectives of the study and research questions will be stipulated in Section 1.6 and Section 1.7, respectively. Lastly, the research design and methodology are introduced in Section 1.8.

1.2 CONCEPT CLARIFICATION

Internationally and within South Africa, the definition for teacher characteristics is quite extensive. Collectively, teacher characteristics can be broadly defined as: teacher qualifications (Bolyard & Moyer-Packenham, 2008; LaTurner, 2002; Darling-Hammond, 2000); related experience (James & Benson, 2008; Onwu, 2000); subject content knowledge (SCK) and pedagogical content knowledge (PCK) (Alder, et al., 2009; Beets, 2009; van Dijk & Kattmann, 2007). Bolyard & Moyer-Packenham (2008) include teacher behaviours, practices, and beliefs as aspects of Science teacher quality characteristics and some research has indicated that teacher beliefs may have influences on the implementation of the curriculum (Gwimbi & Monk, 2003); however, teacher beliefs will not be investigated in this particular research study. Teacher behaviours and practices will be included as part of classroom practices and elaborated on in that section of Chapter 2. Thus, for the purposes of this research, the influences of particular teacher characteristics, such as their professional background, specifically, their professional qualifications and related experience; their subject content knowledge (SCK); and pedagogical content knowledge (PCK) will be given more attention with regards to their interconnection with classroom practices and learner achievement. Classroom practices can be defined as all of the activities and learning strategies that teachers use in their lessons. There is a recorded need in literature for more research in Science education implementation and classroom practices (Abrahams & Millar, 2008; Stols, Kriek & Ogbonnaya, 2008; Fricke, et al., 2008; Hattingh, Aldous & Rogan, 2007; Onwu & Stoffels, 2005; Rogan & Grayson, 2003) and also the processes that are needed in order to achieve the desired outcomes (Stoffels, 2005; Rogan & Grayson, 2003). Learner achievement, in terms of this research, refers to the performance of Grade 12 Physical Science learners on the 2009 National Senior Certificate (NCS) Examinations. The rationale behind defining learner achievement in terms of the 2009 National Senior Certificate Examinations is because these results are a standardised measure of learner achievement and the National Senior Certificate Examinations are currently the only major exit examination in South Africa.

1.3 BACKGROUND TO THE STUDY

This study takes the form of a secondary analysis, using data from the evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools. This project was conducted by the Centre for Evaluation and Assessment (CEA) at the University of Pretoria on behalf of the Gauteng Department of Education (GDE). The evaluation project ran from November 2008 to February

2010 with the aim of evaluating FET Mathematics and Physical Science curricula implementation in Gauteng schools. The overall project design consisted of in-depth case studies of 18 schools, across five quintiles of education, in eight districts (CEA, 2010). The sample of 18 secondary schools was stratified (by District and Quintile) and randomly selected, based on the available budget. The original study was designed in such a way that all the FET teachers of Mathematics and Physical Science from the selected schools were tracked as cases across three data collection phases to measure the extent of curriculum implementation and classroom practice for FET Mathematics and Physical Science classrooms (FET main report). A purposive sampling procedure was used for the secondary data analysis based on the completeness of the data sets and the extent of their participation in the study. The data will be analysed using mixed methods (QUAL + quan) in order to best answer the specific research questions in terms of the interconnection between teacher characteristics, classroom practices, and learner achievement.

1.4 PROBLEM STATEMENT

South Africa has cultural, historical, socio-economic and linguistic contextual complexity which has contributed to challenges in the implementation and attainment of the South African intended curriculum. Specifically, South African learners enter university without the knowledge base that is required, particularly in Science and Mathematics (Jita & Ndalane, 2009; Potgieter, Davidowitz & Mathabatha, 2008; Gopal & Stears, 2007). The reasons that lead up to the fundamental under-preparedness of first year university learners may be a shortage of investigation with regards to the processes that are necessary in order to achieve the desired outcomes. A proposed reason for this gap in literature it that it may be due to the fact that there has been an unbalanced focus on the outcomes of desired educational change in South Africa, specifically on learner achievement (Stoffels, 2005; Rogan & Grayson, 2003).

An area of unique diversity in Science education is at the level of the teacher and is exemplified in teacher characteristics, such as professional qualifications, related experience, and content knowledge, as discussed in Section 1.3. Many issues in South Africa arise at the level of the teacher: firstly, there is the shortage of teachers (Hattingh, Aldous & Rogan, 2007); secondly, a significant number of South African Science teachers are un-qualified or under-qualified with varying amounts of experience, subject content knowledge (SCK) and pedagogical content knowledge (PCK) to teach Physical Science (Jita & Ndlalane, 2009; Fricke, et al., 2008; Hattingh, Aldous & Rogan, 2007; James & Benson, 2008; Dekkers & Mnisi, 2003; Rogan &

Grayson, 2003); thirdly, the quality of teacher education itself has been questioned (Hattingh, Aldous & Rogan, 2007). The reason for the proposed inadequacy of past teacher education in South Africa is largely because of its historical past (Onwu & Mogari, 2004) and variable training for Mathematics and Science teachers in the previous political dispensation (Ono & Ferreira, 2010). One aspect of the recent curriculum documents is that it has left judgements of both depth and breadth up to the discretion of the teacher (Adler, et al., 2009) which means that interpretation of these documents is vastly complicated by the previously defined teacher characteristics.

Historically, South African teachers have and continue to enter the teaching profession via a plethora of routes which may have an impact on the classroom practices that are visible in Gauteng province at the FET Physical Science level. Physical Science teachers in South Africa can gain entry into the profession by completing a B.Sc., B.Ed., PGCE, M.Ed., M.Sc., Teaching diploma (HED), another university degree or possibly only secondary school level education (Beets, 2009; Onwu & Stoffels, 2005). Several research studies have concluded that there is a significant relationship between learner achievement and the teacher's qualifications (Mestry, Hendricks & Bisschoff, 2009; Howie, Scherman & Venter, 2008; Stols, Kriek & Ogbonnaya, 2008; Darling-Hammond, 2000) therefore this study is justified in its aim to look more closely at the interconnection between teacher characteristics, in terms of professional qualifications, Grade 12 learner achievement on National Senior Certificate Examinations and the classroom practices involved.

The second main focus of this research was at the 'learning' level of South Africa's education system and focuses on the attained curriculum, in terms of learner achievement. The National Senior Certificate Examination results in South Africa are the best measure of a standardised assessment and in the absence of standardised international exit examinations they are used to indicate learner ability for university admissions. South Africa has a shortage of learners matriculating with Maths and Science marks that qualify them for further study in the areas of Science, Technology, Engineering and Maths (STEM). The Grade 12 National Senior Certificate Examination results are used for university admissions and the majority of universities in South Africa have had to adjust to low admission standards as a result of poor learner achievement and have incorporated bridging courses and modified their expectations and level of instruction (Potgieter, Davidowitz & Mathabatha, 2008, p.863). In addition to this, many of these learners have serious gaps in their content knowledge which hinders their

potential in university (Fricke, et al., 2008). Thus, many South African learners achieve low results and as a result they are entering university without the knowledge base that is required for tertiary studies, particularly in Science and Mathematics (Jita & Ndalane, 2009; Fricke, et al., 2008, p.65; Potgieter, Davidowitz & Mathabatha, 2008, p.863; Gopal & Stears, 2007, p.15). In order to increase the standards of Grade 12 graduates in Science, it is necessary to identify in which areas teachers and learners are underprepared. Potgieter, Rogan & Howie (2005) have illustrated specific areas of concern in Chemistry. This indicates a need for further investigation as to why learners struggle with these particular topics and if there is an interconnection between the understandings of these topics by the teachers (i.e. SCK); the classroom practices that take place and the learners' level of understanding and achievement.

1.5 RATIONALE FOR THE STUDY

Research in developed countries illustrates that a substantial part of the difference in learner achievement is attributable to teachers and their classroom practices (Darling-Hammond, 2000). The majority of large studies and current research either links Mathematics and Science learning and problems or focuses on Mathematics learning alone (Kanyongo, Schreiber & Brown, 2007). Kanyongo, Schreiber and Brown (2007) found teachers' content knowledge to be an influence on learners' Mathematical achievement. Research has found that teaching practices are a critical factor in promoting learner achievement in Mathematics and may explain some of the variance in learner achievement (Stols, Kriek & Ogbonnaya, 2008). Not many studies have examined the knowledge and understanding of Science teachers in developing countries, as work in these countries has fixated on learner knowledge and dispositions in Science (Jita & Ndlalane, 2009). Jita and Ndlalane (2009) indicate that this is a critical omission in the research on Science education, in South Africa especially, given the emphasis on subject matter knowledge and conceptual development in the latest curriculum reforms.

Bolyard and Moyer-Packenham (2008) reported on a positive relationship between teachers' academic ability (which could be indicated by the completion of higher education degrees and professional qualifications) and learner achievement. These studies provide insight to the interconnection of teacher characteristics, classroom practices and learner achievement in developed nations and for Mathematics education. However, there is a documented need for further research for involving teacher characteristics, classroom practices and learner achievement in Science within the context of South Africa (Adler, et al., 2009; Jita & Ndlalane, 2009; Johnson, Monk & Hodges, 2000).

Darling-Hammond (2000) investigated the relationship between teacher qualifications and learner achievement using American survey data (Schools and Staffing Surveys (SASS)) and data on learner achievement and learner characteristics from assessments administered by the National Assessment of Educational Progress. These analyses used data from a teacher questionnaire, teacher qualifications (teachers' degrees, majors, and certification status), teaching assignments, and average class size. (Darling-Hammond, 2000). Darling-Hammond's (2000) research involved American data bases and is not directly transferable to the South African context; however, it does provide a vision for a type of research design that could offer important clues to a possible interconnection between teacher characteristics (particularly, professional qualifications) and learner achievement.

The variability in teacher formal education and training over the past thirty years in South Africa has made it difficult for researchers to make links between teacher qualifications, classroom practices and learner achievement due to the multitude of ways in which teachers have, and continue to, gain entry into the teaching profession. The development of a classification scheme for Science teacher qualifications and other teacher characteristics would better facilitate analysis of the possible interconnection between teacher characteristics, classroom practices and learner achievement. A modified classification scheme can be developed using aspects of LaTurner's (2002) teacher qualifications categories (refer to the literature review for a schematic representation) and Rogan and Grayson's (2003, p.1190), "profile of the capacity to support innovation" (refer to the literature review for a schematic representation) in order to catalogue teacher characteristics for South African Science teachers. Any classification scheme will be a generalisation; however, it may offer value for policy-makers and researchers. It is important to keep in mind that the purpose of a classification scheme should not be to 'label' individuals or school, but should serve a function to better understand and serve their needs, particularly in-service education and training (INSET) programmes (Rogan & Grayson, 2003).

The processes of curriculum implementation can be investigated by observing teachers' classroom practices. "What learners learn depends on what is taught" (Dekkers & Mnisi, 2003), so it is necessary to look further than examination achievement results and investigate what and how Science teachers are teaching and what is occurring in the classrooms as a result of the teacher's classroom practices. A Science teacher's classroom practices are based on the

extent of their scientific understanding and skills (SCK), what they are able and willing to teach, and on what they believe they are actually required to teach (PCK) (Dekkers & Mnisi, 2003). It is important to reiterate that what teachers know and what they are qualified to teach does not necessarily always get taught, and "...it is not simply a matter of how much Science or Mathematics teachers know, but the ways in which they understand and can deal with the Science and Mathematics they need to know" (Adler, et al., 2009).

As a consequence of the lack of effective classroom practices and related theoretical debates, various approaches to professional development have emerged for Science and Mathematics teachers (Jita & Ndlalane, 2009, p.58). Teachers have identified a need for INSET that will assist them in identifying and implementing their personal "next steps" with consideration of the contexts in which they teach (Rogan, 2004, p.178). A classification scheme will be useful in advising appropriate in-service training for South African teachers based on their formal qualifications and the classroom practices that take place in their classrooms. This is necessary because of the differences in teacher qualifications in South Africa due to the various routes in which teachers have obtained their professional qualifications and entry into the profession over the past several decades.

The academic subject area investigated in this research is Grade 12 Further Education and Training (FET) Physical Science. The reason that this level of focus was selected was based on personal teaching experiences and a reported gap in the literature at this level. According to researchers, there has been an unbalanced focus on the outcomes of desired educational change (Stoffels, 2005; Rogan & Grayson, 2003), specifically learner achievement, which has seemingly neglected the aspects of the processes that are needed in order to achieve the desired outcomes. When viewing the system in terms of inputs, processes and outcomes, there is a need for investigating the inputs (such as, teacher characteristics and the intended curriculum) and processes (classroom practices and the implemented curriculum) in order to better understand the shortfalls in terms of outputs (learner achievement).

1.6 OBJECTIVES OF THE STUDY

The aims of this study can be realised through data collection by way of the Gauteng Department of Education's "Evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools".

1. To develop a framework for classifying teacher characteristics within the context of the study by using aspects of LaTurner's (2002) teacher qualifications categories and Rogan and Grayson's (2003) 'profile of the capacity to support innovation';
2. To report on the classroom practices for each category of teacher characteristics in the FET study sample population using the above mentioned classification framework for teacher characteristics; and
3. To report on the extent to which the pass rates of the Grade 12 classes for the National Senior Certificate Examination results are related to each category of teacher characteristics and classroom practices.

1.7 RESEARCH QUESTIONS

Flowing from the objectives of the study, the main research question is: *What is the interconnection between Grade 12 Physical Science teacher characteristics, classroom practices, and National Senior Certificate Examination results in Gauteng secondary schools?*
From the main research question, the following sub-questions can be identified:

- What are the different categories of teacher characteristics in the FET study sample population?
- What are the various classroom practices that are used by teachers in each of the categories of teacher characteristics?
- To what extent are the 2009 Grade 12 National Senior Certificate Examination results related to teacher characteristics and classroom practices?

1.8 RESEARCH DESIGN AND METHODOLOGY

The study followed a mixed methods research design to perform a secondary analysis of the data from the 'evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools' project that was conducted by the Centre for Evaluation and Assessment (CEA) at the University of Pretoria on behalf of the Gauteng Department of Education (GDE). A mixed methods research design was used to perform a secondary analysis of the data in order to answer the main research question,

specifically, to identify the interconnection between teacher characteristics (such as, formal qualifications, experience, and knowledge); classroom practices; and learner achievement. Both quantitative and qualitative data was collected and used in conjunction to provide a detailed description and to best understand the research problem. However, the qualitative data will take priority (QUAL + quan). The rationale for the methodology is elaborated on in Chapter 4.

1.9 CONCLUSION

The first chapter served as an introduction and provided background information on Science education both, internationally and within South Africa. The aims of the study and problem statement were presented, as well as, an overview of the study. The key definitions within this study were defined and explained, the rationale behind the study was discussed and lastly, the research questions were stipulated. Chapter 2 reviews the existing literature that underpins the theory in relation to the concepts that were introduced in the first chapter. Specifically, the South African National Curriculum, teacher characteristics, such as teacher professional qualifications, teacher experience, subject content knowledge (SCK), pedagogical content knowledge (PCK), classroom practices, and learner achievement. Following this, Chapter 3 is dedicated to the conceptual framework guiding this study and contributing literature is presented. The chapter to follow, namely Chapter 4, focuses on the research design and methodology. Various issues relating to sample selection, instrument selection and data collection are explored and the data analysis methods are discussed. Finally, the methodological norms, ethical considerations and limitations to the study are presented. Chapter 5 presents a discussion of the data and the results of the study and Chapter 6 presents the conclusions that have been drawn from the study, as well as, recommendations and implications for future research in this field.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to discuss the literature that relates to the various components that were introduced in Chapter 1. Section 2.2 presents a general overview to the context of South African schools. Related literature has been used to provide the theory that underpins the secondary analysis study and ultimately the main research question. This is specifically to illustrate the interconnection between teacher characteristics, classroom practice and learner achievement in Grade 12 Physical Science. The literature review chapter discusses South African and International research that has been conducted in the areas of teacher characteristics (Section 2.3), classroom practices (Section 2.4) and learner achievement (Section 2.5). Section 2.3 offers several sub-sections which elaborate on the teacher characteristics that have been defined in literature. Specifically, various professional qualifications and models of teacher education, as well as, a discussion of two American research studies that offer promising insights with regards to teacher qualification categories and learner achievement, are examined in Section 2.3.1. Section 2.3.2 serves to provide an overview of professional development activities and related literature. Following this, additional literature on teacher characteristics is presented and entitled related experience in Section 2.3.3. The theme of content knowledge, as identified in the literature is divided into subject content knowledge (SCK) and pedagogical content knowledge (PCK) in Section 2.3.4.1 and Section 2.3.4.2, respectively. The vast descriptions of SCK and PCK in literature have been realised; however, only that which is relevant to the depth of this study has been addressed in this chapter. Finally, the literature review presents a discussion of recent literature related to classroom practices in Section 2.4 and learner achievement in Section 2.5. The conceptual framework and associated literature will be presented and discussed as a separate chapter to that of the literature review and can be found in Chapter 3.

2.2 SOUTH AFRICAN CONTEXT

In the last two decades, in line with major political changes, the South African educational system has undergone frequent restructuring with regards to educational infrastructure and resources in order to devise a system that is based upon the principles of *equity*, *quality*, and *access* (Howie & Scherman, 2008). However, the intended changes within South African

schools have been impeded by the vast and complicated contextual factors found in the country. These factors vary from school to school and district to district, making it difficult to devise policies that fit the various contexts. It has been reported that policies and programmes that are successful in an American or European context are often unsuccessful in developing nations (Johnson, et al., 2003, p.86).

The contextual factors that hinder policy implementation and curriculum goals in South Africa have been frequently identified and regularly addressed in research. These contextual factors which have an effect on education provision in the South African context include large, under-resourced classrooms with a shortage of desks, texbooks, equipment, space, computers, internet connections, and so on (Jita & Ndalane, 2009; Fricke, et al., 2008; Howie & Scherman, 2008; Howie, Scherman & Venter, 2008; James & Benson, 2008; Makgato, 2007; Onwu & Stoffels, 2005; Onwu, 2000). However, most importantly for the teaching of Physical Science, there is an uneven distribution of resources and functioning Science laboratories (Fricke, et al., 2008, p. 70) which is further intensified by the situation in most South African schools, where the teacher to learner ratios in Science classes are often so high that the teacher is limited to performing only practical demonstrations (James & Benson, 2008). Other socio-economic factors, relating to changing demographics within the schools (Mestry, Hendricks & Bisschoff, 2009, p. 478; Steyn &. Mentz, 2008, p. 680) such as poverty, the increasing numbers of people residing in informal settlements, and various immigration issues may also play a role in the dynamics of a school. In addition to these socio-economic factors, there are language factors that need to be recognised as South Africa has eleven official languages. Despite this linguistic diversity, the majority of learners are only taught in either English or Afrikaans at the FET phase, resulting in the vast majority of learners not being educated in their home language (Howie & Scherman, 2008). Furthermore, many South African Science teachers are often found to be under-qualified, with varying experience and subject content knowledge (SCK) and pedagogical content knowledge (PCK), to teach Physical Science (Jita & Ndalane, 2009; James & Benson, 2008; Dekkers & Mnisi, 2003). Exacerbating the situation is the non-availability of productive and valuable workshops and in-service training in South African for Science teachers to develop their knowledge to become fully equipped to teach the expected curriculum (Aldous, 2004, p. 65).

In her USA study, Darling-Hammond (2000, p.23), reported that:

> *Learner characteristics such as poverty, non-English language status, and minority status are negatively correlated with learner outcomes, and usually significantly so. These learner characteristics are also significantly and negatively correlated with the qualifications of teachers; that is, the less socially advantaged the learners, the less likely teachers are to hold full certification and a degree in their field and the more likely they are to have entered teaching without certification*. (Darling-Hammond, 2000, p.23)

While it is realised that the previously identified socio-economic, linguistic and resource-related factors are of importance when investigating the intended, implemented and attained curricula (IEA, 1998); the focus of this research was on teacher characteristics and classroom practices and how these factors interconnect with learner achievement in Physical Science.

2.3 TEACHER CHARACTERISTICS

Internationally and within South Africa, the definition for teacher characteristics is quite extensive. Collectively, teacher characteristics can be broadly defined as: teacher qualifications (Bolyard & Moyer-Packenham, 2008; LaTurner, 2002; Darling-Hammond, 2000); related experience (James & Benson, 2008; Onwu, 2000); subject content knowledge (SCK) and pedagogical content knowledge (PCK) (Rollnick & Davidowitz, 2011; Adler, et al., 2009; Beets, 2009; van Dijk & Kattmann, 2007). Bolyard and Moyer-Packenham (2008) include teacher behaviours, practices, and beliefs as aspects of Science teacher quality characteristics and some research has indicated that teacher beliefs may also have influences on the implementation of the curriculum (Gwimbi & Monk, 2003); however, teacher beliefs will not be investigated in this particular research study. Teacher behaviours and practices will be included as part of classroom practices and elaborated on in that section of Chapter 2. Thus, for the purposes of this literature review, the influences of particular teacher characteristics, such as their professional background, specifically, their professional qualifications and related experience; their subject content knowledge (SCK); and pedagogical content knowledge (PCK) will be given more attention with regards to their interconnection with classroom practices and learner achievement.

2.3.1 Professional Qualifications

Science teacher professional qualifications in South Africa have and can be obtained through several routes, including, but not limited to a: Diploma (HED); Post-graduate Certificate in Education (PGCE); Bachelors of Education (B.Ed.); Bachelors of Science (B.Sc.); Honours degree (B.Ed. (Hons), B.Sc. (Hons)); Masters Degree (M.Ed., M.Sc.); and/or Doctorate Degree

(Ph.D.Ed, Ph.D.Sc). Globally, there has been an increase in surveillance and control with regards to the evaluation of teacher qualifications and experience. This has largely been done in order to devise detailed salary scales for teachers, where teacher qualifications are the basis for salary grids and where performance and professional development, along with experience, serve to determine a teacher's salary (Wrigley, 2007, p.5). The rationale for these salary scales has grounding in several national and international studies that have presented findings of a positive relationship between teacher qualifications and learner achievement (Bolyard & Moyer-Packenham, 2008; Stols, Kriek & Ogbonnaya, 2008; LaTurner, 2002; Darling-Hammond, 2000).

Darling-Hammond (2000) found that a full teacher certification and a major in the subject that is being taught is a more influential predictor of learner achievement than teachers' acquisition of higher degrees. Post-graduate degrees, such as masters and doctorate degrees, are relatively weaker measures of teacher knowledge, given the wide range of content that they can include. For instance, post-graduate degrees could range from specialist degrees that are directly related to teaching (for example, degrees in literacy or special education) to others that are less connected to teaching (such as management) (Darling-Hammond, 2000). In addition to the research that has been presented by Darling-Hammond, LaTurner's (2002) findings also suggest that teachers who are less concerned with earnings and social status are more likely to stay in the profession, and often possess a teaching qualification only. He also noted that frequently these teachers entered into the profession because they are either intrinsically motivated to teach, or they were unable to gain entrance to other certifications. Consequently, the teachers with only a teaching qualification are somewhat limited with regards to career options and should be developed professionally. This development should be focused on keeping them contented as teachers, with the goal of advancing their classroom and assessment practices. Increasing the PCK and SCK of these teachers after they enter into the profession is one way to qualifications of teachers, especially in less advantaged schools where shortages occur (LaTurner, 2002).

A variety of literature points towards an interconnection between teacher qualifications, the types of schools in which they teach, and retention rates. It has been noted that teachers who have minimal or no qualifications tend to be employed in less advantaged schools and those with higher qualifications are probable at more advantaged schools (Howie, Scherman & Venter, 2008; LaTurner, 2002; Darling-Hammond, 2000). LaTurner (2002) found that teacher

who possessed subject qualification only, without a teaching qualification, were more likely to teach in private schools, and are the least likely among all of the groups to plan on teaching in the future. Many Science teachers in South Africa are either under-qualified or not qualified to teach Science and work in contextually challenging schools (Dekkers & Mnisi, 2003; Fricke, et al., 2008; Jita, 2009). This is a point of interest because the shortage of professionally qualified Science teachers (Jita & Ndlalane, 2009; Onwu & Mogari, 2004) could possibly be interconnected to the widespread low achievement of South African learners in Science (Ono & Ferreira, 2010).

Aside from professional qualifications, other characteristics have been incorporated in defining teacher quality. Teacher quality may have different meanings depending on the perspective from which it is discussed; such as, that of researchers, policymakers, school management or teachers. A 'well-qualified' Science teacher can be depicted as one who has an in depth understanding of the Science concepts that need to be taught (SCK), who uses apposite instructional techniques (PCK), and who commits to lifelong learning and improvement (Bolyard & Moyer-Packenham, 2008). The U.S. Department of Education released the "No child Left behind" (NCLB) Teacher Quality mandate which articulates that a highly qualified teacher is a person who has a minimum of a bachelor's degree in the subject that they teach; holds full certification or has passed a teacher licensing examination; and holds a teaching license that is not classified as emergency, temporary, or provisional. The NCLB teacher quality mandate in the United States goes even further to define that a "highly qualified" teacher must demonstrate competence in subject knowledge and teaching (Bolyard & Moyer-Packenham, 2008). Despite discrepancies in the definition of what exactly defines quality teaching, "quality teaching is recognised as central to any education system, and teacher education is, in turn, central to the development of the profession" (Adler, et al., 2009, p. 28). Thus, it makes logical sense that increasing the level of Science teacher 'quality' should theoretically lead to an increase in learner interest in Science and related careers, which will, in turn, result in more learners entering the tertiary field of Sciences (Clark, 1988 in Griffiths, 2000). Increasing the amount of people entering into STEM careers and tertiary studies is an international objective that allows countries to be more globally competitive in areas of Science, maths, and technology (Kachelkoffer, 1995).

The importance of research with regards to teacher qualifications and the subject area of Science is exemplified by research findings that indicate that the path of Science teacher

preparation does influence learner outcomes, in terms of academic achievement and interest in the subject. It has been noted that teachers who possess both teacher education and Science qualifications will be more likely to positively influence learner achievement and reduce dropout rates (LaTurner, 2002; Darling-Hammond, 1999a, b). Additionally, it is has been recorded in literature that teachers who only possess only an education degree had no impact on their learner's Science achievement (Bolyard & Moyer-Packenham, 2008). The findings from a study on the influence of teachers' background on learner achievement in mathematics in Lesotho reported that there is a statistically significant relationship between learner achievement in mathematics and the teacher's qualifications. In this particular study, teacher qualifications were measured in terms of whether the teacher had a degree, a diploma or a certificate (Stols, Kriek & Ogbonnaya, 2008). This further substantiates a need for additional research in terms of teacher education and subject specialisation in South Africa and internationally (Adler, et al., 2009; Darling-Hammond, 2000). The underlying assumption is that if effort is made to enhance teachers' understanding of Science then their content knowledge will be passed on to their learners and will eventually be evident in learner assessment results (Mestry, Hendricks & Bisschoff, 2009; James, 2008).

There are several models of pre-service teacher education and training (PRESET) that are predominant globally. The different models of PRESET can be categorised into the consecutive model, the integrated model and the concurrent model for teacher training. The various models of PRESET are part of a continuous international debate concerning the context of the attainability, sustainability and effectiveness of each model (Van der Walt & Fowler 2006). It is important that universities and higher education institutions consider the discrepancies between how teachers were taught when they were in school, and how they should be teaching the current curriculum, when developing PRESET programmes (Adler, et al., 2009). Each of the three models was developed to serve particular needs in teacher education (Steyn & Mentz, 2009) and will be briefly discussed in the following paragraphs.

The first two models for teacher education, namely the integrated and concurrent models, are designed for individuals that have chosen education as a vocation and wish to prepare themselves as teachers. In the integrated model for teacher training, subject content and the methodology to teach this content are usually combined in the same module. The subject content knowledge (SCK) will focus on the specific competencies necessary for the pre-service teachers to implement the intended curriculum to their phase of subject specialisation (Steyn

& Mentz, 2009). In the concurrent model, pre-service teachers are required to take the major academic subjects related to their degree of specialisation. Teachers who choose this route will usually study alongside of learners who are registered in the generic three-year degree at the same time as they study the subject specific methodology to teach in that field (Steyn & Mentz, 2009). Consequently, the teachers who partake in the concurrent programme would be exposed to a more diverse and intense level of subject specialisation than those who are studying by way of the integrated model and exposed only to the content that they will eventually be required to teach within their classrooms. According to Adler, et al. (2009), many of the B.Ed. learners that are preparing to teach Science in the FET phase would not have been accepted into B.Sc. programmes based on their Grade 12 results. However, many of these learners can become effective Science teachers if they are provided with the opportunities and support to develop their subject content knowledge throughout their studies (Adler, et al., 2009). Regardless of the model followed, both of these routes will result in a teacher with a Bachelor of Education (B.Ed.) degree in South Africa.

As an example, the model of education that is followed at the University of Pretoria for acquisition of a B.Ed. is in line with the concurrent model. According to the University of Pretoria Regulations and Syllabi (Faculty of Education, 2013), completion of a B.Ed. in FET Physical Science requires completion of fundamental modules, core modules and elective modules. The fundamental modules are academic information management, literacies in education, and academic service learning. The core modules involve six education modules, professional studies, and fourth year research methodology and teaching practice modules. A fourth year module in Physics and Chemistry Education that is in line with their previous elective modules specialising in various intensities of Maths, Physics or Chemistry (Faculty of Education, 2013). It is intended to be to such a standard that the individuals who follow the concurrent model will be exposed to subject content at an intensity that is similar to those who go through a programme in line with the consecutive model, such as the Post-Graduate Certificate in Education (PGCE) programme.

The Post-Graduate Certificate in Education (PGCE) programme is the consecutive model of teacher education that is used in South Africa. The consecutive model provides the opportunity for pre-service teachers to prepare themselves as subject specialists during a three or four year general degree and then to prepare themselves during a one-year professional study period as teachers (Steyn & Mentz, 2009). In the case of the consecutive model, a qualified FET Science

teacher should ultimately generally gain entry to the profession by way of completing a three or four year Bachelor of Science or honours degree (B.Sc. or B.Sc (Hons.)) followed by a PGCE. According to the University of Pretoria 2013 admission requirements, to gain entry into the PGCE programme at the FET phase, an individual must possess "at least one degree module passed at the third-year academic level (300) which corresponds with a relevant school subject" as specified in the programme modules (Faculty of Education, 2013, p. 33). Regardless of the academic institution that is attended, the overall aim of the consecutive model of education is to consolidate SCK and PCK in preparation for teachers to work within a range of contexts and to promote authentic learning both at a national and international level (Carl, 2008). As an example, a PGCE at the University of Pretoria consists of a university-based learning (UBL) and a school-based learning (SBL) component. The UBL component is presented in the format of learning workshops that consist of fundamental, core and elective modules that are prescribed by the field of specialisation. The SBL component is designed to provide the PGCE learners with an opportunity to engage in education practice while they are supported and assessed by qualified mentor teachers and university lecturers (Faculty of Education, 2013).

Essentially, regardless of which PRESET model of education has been followed, each new teacher will have variable degrees of competency in terms of their SCK and PCK (Adler, et al., 2009; Steyn & Mentz, 2009). One problem is that many South African teachers have been prepared to teach content that they may not have done when they were at school, and to teach in ways that are different from what they experienced as learners (Adler, et al., 2009). In many cases, South Africa teachers are hindered by their own previous education because they will tend to teach in the manner in which they were taught. This influence is important because many of the teachers lack exposure to appropriate SCK during their own secondary school education (Stears & James, 2004). There is thus a need for teacher professional development that is designed to impact teacher perceptions and their SCK so that they will be better equipped to teach their learners in the manner that is intended by the NCS within the context of their schools (James & Benson, 2008).

2.3.2 Professional Development

Professional development activities may include individual development, continuing education, and in-service education, as well as, curriculum writing, peer collaboration, study groups, and peer coaching or mentoring (Ferraro, 2000). It has been documented that in order for educational reform to be successful, teachers must be included and developed

professionally before advances can occur (Ono & Ferreira, 2010). Nonetheless, professional development activities continue to be neglected in many developing countries. The rationale for this inattention is often due to budget constraints and heavy emphasis on pre-service education and training (Leu, 2004 in Ono & Ferreira, 2010). Professional development can be time consuming and costly which is why school reformers are so interested in the role that effective professional development may have in improving Science teacher classroom practices (James & Benson, 2008).

The implementation of new pedagogical strategies requires effective teacher development that aims to change and develop teachers' views on teaching, learning and the nature of their subject area (Ono & Ferreira, 2010; Beets, 2009). Whilst a numerous descriptions exist with regards to effective professional development, it is widely accepted that it must be ongoing, school-based, context specific, and address both the needs of the learners and the teachers in a collaborative, progressive approach (Adler, et al., 2009; Fricke, et al., 2008; James & Benson, 2008). Rogan (2006) goes further in that both content knowledge and teaching strategies should also be encompassed. Professional development programmes should be learner centred, knowledge centred, assessment centred and community centred to optimise teacher learning (Ono & Ferreira, 2010). Overall, the level of development should be teacher and context specific, occur in small incremental steps, aim to develop both SCK and PCK, with regular follow-up to ensure that the new strategies are being successfully implemented in the context so that further interventions are able to build on the newly developed knowledge of the teachers (Ono & Ferreira, 2010; Adler, et al., 2009; Beets, 2009; Fricke, et al., 2008; James & Benson, 2008; Rogan, 2006).

A supporting factor for intervention in the form of professional development in South Africa is that teachers generally teach in the manner in which they were taught. This is exemplified by the historical and linguistic inequalities that existed within South Africa. As a result, many South African teachers are hindered in their acquisition of content knowledge by the fact that many of them did not get exposed to adequate subject content when they were in school (Stears & James, 2004) and they were taught in conventional, discipline-based, teacher-centred classrooms whilst they are now expected to teach in trans-disciplinary, society-integrated, globally-relevant, learner-centred classrooms (Onwu, 2000). Many teachers in South Africa comment on how the physical environment of the classroom has a strong influence on what they can do in the classroom. The physical environment includes the various contextual factors

were discussed in Chapter 1 that contribute to making South African schools uniquely complex. Furthermore, teachers also comment on how social and political factors influence the range of strategies they can use in the classroom and ultimately their PCK. Thus, the challenge for those responsible for teacher development is to find ways to strengthen and support activities within the various contexts of South African schools. In addition to understanding learning and development in social and cultural contexts, professional development must aim to increase teacher quality in terms of content knowledge (Hammond-Darling 2006, 2000) whilst it is also necessary to influence teachers' perceptions, PCK and SCK, in addition to changing their beliefs regarding professional development (James & Benson, 2008). Various strategies have been evaluated and continue to attract interest, some of these development activities are mentorship programmes and clusters; the cascade approach; and formal workshops.

Mentorship programmes are said to be the most cost effective and sustainable form of professional development for teachers (Fricke, et al., 2008). These programmes utilise experienced teachers to mentor other teachers, within their own classrooms, while taking into consideration various contextual factors in the selection of the intervention strategies. It is important to recall that professional development activities should be ongoing, school-based, context specific, and address both the needs of the learners and the teachers in a collaborative, progressive approach (Adler, et al., 2009, p.28; Fricke, et al., 2008; James & Benson, 2008). This is why the use of clusters and mentor teachers has a lot of potential to be a positive mode of professional development in South Africa, both economically and developmentally. It is obvious that clusters that combine teachers who possess a variety of professional qualifications and experiences will only add value to the cluster and mentorship programmes. Jita & Ndalane (2009) suggest that each cluster should have a mentor teacher to model quality teaching methods and facilitate sharing of SCK and PCK in various contexts. This cluster leader should be identified as a well-respected teacher within the context of the cluster group, who demonstrates exemplary SCK and PCK and is specialist teaching qualified, in order to translate best practices into the cluster context (Jita & Ndalane, 2009; Fricke, et al., 2008), however, this is not necessarily what happens in most cluster and training groups in South Africa.

Another method of professional development that is commonly utilised in developing nations is the cascade approach, and is considered to be one of the cost-saving ways to implement INSET. The cascade or "multiplier" approach to professional development transmits the knowledge or information from experts and specialists to groups of teachers who further pass

on the information and knowledge to more groups of teachers through formal courses. This model is advantages if it is used as intended, in such a way that it allows for training in stages so that progress can be monitored and information can be disseminated quickly and to a large number of teachers. In theory cascade training is cost effective, as those who have been trained can then train others, thus limiting expenses (Ono & Ferreira, 2010, p. 60). Consequently, the cascade approach was selected by the South African Department of Education and applied throughout the country in an attempt to prepare teachers to implement the new curriculum for C2005 and OBE (Ono & Ferreira, 2010).

Many African teacher and curriculum development projects in the past have ultimately not been successful because they did not fit either with the social expectations or the level of resources available (Johnson, Hodges & Botha, 2003). The professional development activities that were implemented when c2005 and OBE were introduced in South Africa, such as the thousands of workshops and conferences, reportedly led to no significant change in practice when the teachers returned to their classrooms (Ono & Ferreira, 2012, p.60). The success of international interventions within the Science curriculum in South Africa has been limited by the contextual factors that were discussed in the first chapter, as well as, by teacher characteristics and classroom practices. Various types of INSET and intervention programmes have been tried in South Africa but many have been unsuccessful in raising teacher competency in terms of SCK and PCK. Teachers in South Africa have been given resources during INSET and often those resources go unused. This is largely because the teachers are still without the skill and knowledge of how to successfully implement Science at FET level.

2.3.3 Related Experience

A teacher's classroom practices are affected by their past and present circumstances and their experiences related to teaching (Pinto, 2005). Teaching experience is generally measured in terms of total years of teaching and it has been reported that there is positive relationship between teachers' experience and Science achievement in some studies (Bolyard & Moyer-Packenham, 2008). According to Darling-Hammond (2000), many studies have established that inexperienced teachers, specifically those with less than three years of experience, are typically less effective than more senior teachers. However, she also specifies that the benefits of experience appear to level off after about five years. Darling-Hammond (2000) hypotheses that this trend in experience may be for the reason that older teachers tend to participate in less professional development, or that uneven effects of experience in cross-sectional studies may

be the result of cohort effects (for example, cohorts of teachers hired in times of shortage may be less well-qualified than those hired when schools can be more selective) or of attrition effects (for example, disproportionate early attrition of more able teachers may leave a less capable senior force on average). Furthermore, experience is also correlated with teacher education and certification status and as a result these variables may be confounded in some analyses (Darling-Hammond, 2000).

2.3.4 Content Knowledge

Teacher qualifications and related experience are two of the teacher characteristics that have been discussed previously in the literature review. Both of these teacher characteristics influence a teacher's subject content knowledge (SCK) and pedagogical content knowledge (PCK). The concept of subject content knowledge (SCK) has been introduced in the previous sections, is widely discussed in education related literature, and can be defined as the depth of understanding that a teacher has with regards to the subject content that they are required to teach (Steyn & Mentz, 2009; Bolyard & Moyer-Packenham, 2008). The extent of a teacher's SCK has been indicative of teacher quality and ultimately learner achievement (Bolyard & Moyer-Packenham, 2008; Darling-Hammond, 2000). Pedagogical content knowledge (PCK) is defined as "knowledge which goes beyond the knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" (Shulman, 1986, p. 9). It is a combination of SCK, contextual knowledge, and pedagogical knowledge that enables the teacher to best select classroom practices in order to make the curriculum content accessible to their learners by having an awareness of what facilitates or hinders learning in the context in which they teach (Beets, 2009; Bolyard & Moyer-Packenham, 2008; van Dijk & Kattmann, 2007). Jita and Ndalane (2009, p.60) indicate a need for more detailed investigations of how teachers share and exchange PCK and SCK. This is reinforced by Loughran, et al. (2004, p. 370) in that "teachers' professional knowledge is difficult at best to categorise and therefore exceptionally difficult to articulate and document". As previously discussed in the section on professional teacher qualifications, all models of teacher education result in a new teacher having various degrees of competency with regards to their SCK and PCK, regardless of the educational model that was followed (Adler, et al, 2009; Steyn & Mentz, 2009).

2.3.4.1 Subject Content Knowledge (SCK)

In addition to professional qualifications and related experience, subject content knowledge (SCK) is presumed to be indicative of teacher quality and ultimately learner achievement (Bolyard & Moyer-Packenham, 2008; Darling-Hammond, 2000). Over the past couple of decades, several researchers have tried to measure teachers' SCK for specific topics and Potgieter, Rogan and Howie (2005) identifies specific topic areas in the FET Chemistry curriculum in which learners typically have inadequate content knowledge. The chemistry topics electrochemistry, acids and bases, and chemical equilibrium were identified as 'difficult topics' in South Africa. According to Abrahams and Millar (2008), teachers must be proficient in terms of SCK and have enough confidence to promote exploration activities in their classroom practices which may lead to more complex thinking and questioning from their learners. One way that teachers can promote exploration in relation to the content knowledge that they share with their learners is to select practical activities and tasks that link knowledge with the application to society components of the curriculum. This falls in line with the expectations of OBE and may also increase the interest in tertiary Science education. It is also suggested that in order to correctly use a model, make an analogy, or apply knowledge in new contexts, a person must have a clear understanding of the concepts. This means that in order to increase the quality of learning, teachers must have above adequate understanding of the SCK and the PCK to teach it within the context of their classrooms.

2.3.4.2 Pedagogical Content Knowledge (PCK)

Pedagogical content knowledge can be further explained to be knowledge that "represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1987, p. 8). Bell (2005 in Beets, 2009) further defines pedagogy as "more than just best practice; it is more than the techniques or strategies of arranging the seating in the classroom, choosing the materials and equipment to be used, preparing a lesson, or managing learning activities for learners during a lesson" (Beets, 2009, p. 1181)

Identifying the relationship between SCK and PCK is a very challenging task (Adler, et al., 2009); however, a few studies have reported that effective INSET may have positive effects on teachers' knowledge and classroom practices (Bolyard & Moyer-Packenham, 2008). As discussed previously in the section on teacher qualifications, it is important to note that teachers

entering into university programmes, and ultimately the teaching profession, possess varying levels of competency in terms of SCK and PCK (Adler, et al., 2009; Steyn & Mentz, 2009; van Dijk & Kattmann, 2007). This is why it is important to take an inventory of where teachers are with regards to their SCK and PCK before modelling the next level of classroom practices, assessment, and so forth, or else it is just a waste of money and time.

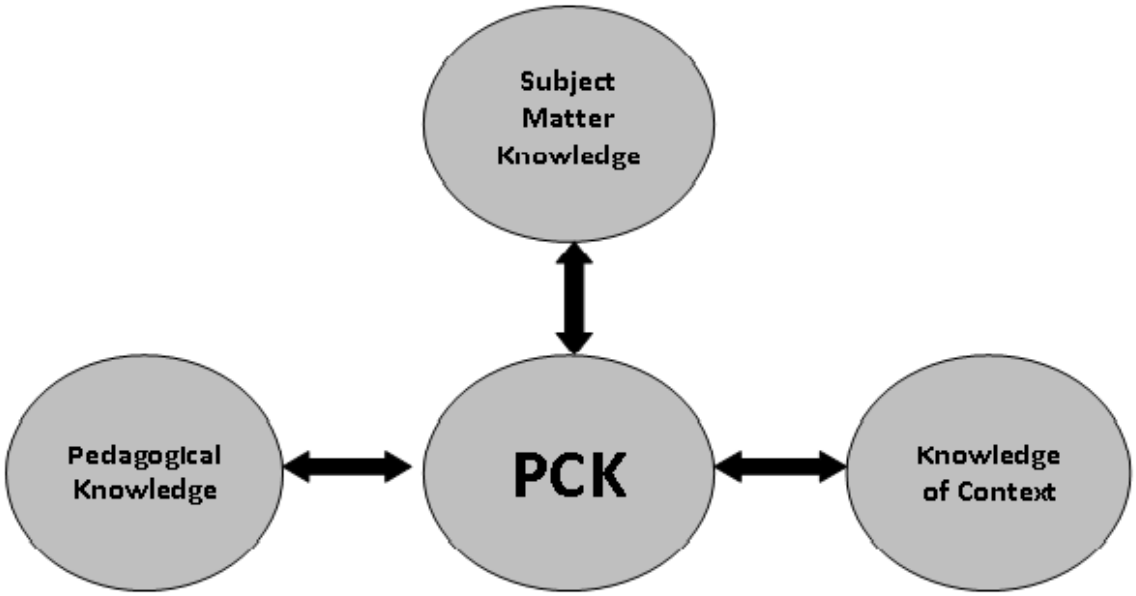

Figure 2.1 - The model of teacher knowledge. In this model PCK is presented as a unique knowledge domain. (van Dijk & Kattmann, 2007, p.888)

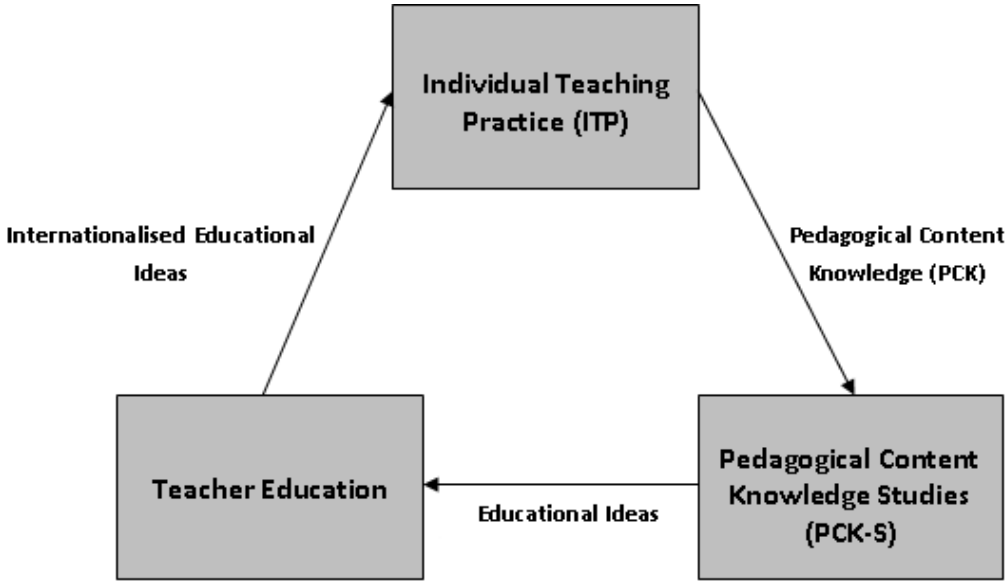

Figure 2.2 - A model which aims to clarify the distinction between PCK, the personal knowledge domain of the teacher, and educational ideas, the results from PCK-S. (van Dijk & Kattmann, 2007, p.894)

2.4 CLASSROOM PRACTICES

Classroom practices can be defined as all of the activities and strategies that teachers use to facilitate learning within their lessons. These classroom practices are chosen based on a teacher's pedagogical content knowledge and their personal belief of what will be the most effective way to implement the curriculum within the context in which they teach. Their choices are influenced personally, socially and contextually by resource availability; learner, parent and administration expectations; their personal PCK and SCK; and curriculum specifications (James & Benson, 2008; Gwimbi & Monk, 2003).

Classroom practices range from teacher-centred to learner-centred depending on the nature of the activity. Teacher-centeredness refers to level of control that the teacher possesses in a particular activity or situation, particularly that the teacher is leading the activity. An example of this would be when the teacher uses demonstrations to promote a limited form of inquiry with regards to the practical components of the curriculum (Rogan & Grayson, 2003). Learner-centeredness, on the other hand, refers to activities that are introduced by the teacher; however, primary control and exploration is in the hands of the learners. An example would be when the learners design and do their own 'open' investigations (Rogan & Grayson, 2003). All of the classroom practices in this chapter will be discussed with reference to these terms.

Teacher beliefs fall under the definition of teacher characteristics as previously defined and discussed in Chapter 1, as well as, earlier in Chapter 2. However, teacher beliefs also have an impact on the implementation of the curriculum and on the selection of classroom practices. This is because the classroom practices that a teacher chooses for a particular lesson are based on several factors, such as their PCK, beliefs on how learners acquire knowledge, expectations, and their opinion and understanding of the intended curriculum (Gwimbi & Monk, 2003; Aldous, 2004). A discussion of curriculum in terms of related literature has been included in Chapter 3 as part of the conceptual framework. It has been suggested previously in research that classroom practices that occur within a constructivist context are preferable and make it feasible for learners to actively integrate prior learning with current classroom experiences in order to develop new knowledge (Anderson, et al., 2007). Accordingly, it has been documented that teachers who have a tendency to utilise constructivist classroom practices are likely to teach within school contexts that allocate sufficient contact time; resources and ongoing professional development (Gwimbi & Monk, 2003). Selecting effective classroom practices is essential for the successful implementation of the curriculum. Thus, identifying and sharing the types of classroom practices that motivate and engage learners is beneficial to the teaching profession and may help to improve teaching quality, effectiveness, and accountability (Akinsola & Ifamuyiwa, 2008).

Certain classroom practices seem to be predominant in certain contexts and may be associated with certain teacher characteristics. Looking more closely at these interconnections in South Africa could prove to be invaluable in informing teacher professional development and selection of relevant classroom practices. For example, Abrahams and Millar (2008) found that teachers with subject specialisation are more likely to make use of a variety of resources and classroom practices and are unlikely to rigorously follow schemes of work, textbooks or prescribed worksheets as a result of their acquired competency in SCK (Abrahams & Millar, 2008). Although curriculum reforms in South Africa specify the importance of inquiry-based learning and the application of Science in society, in addition to traditional knowledge components, most textbooks continue to provide limited opportunities for learners to engage in open investigation and exploration (Anderson, et al., 2007). As a result, teachers who rely heavily on textbooks as guides actually limit the breadth of questioning and the amount of exploration that can occur within their classrooms. Such practice is detrimental to learners who are thought to benefit in environments that promote inquiry and application in learner-centred classroom practices.

The classroom practices discussed in this literature review vary in approach and can be listed as: formal presentation, whole class teacher-guided questioning, group work/cooperative learning (Akinsola & Ifamuyiwa, 2008; Stols, Kriek & Ogbonnaya, 2008), practical work (Abrahams & Millar, 2008; Fricke, et al., 2008; Hattingh, Aldous & Rogan, 2007; Onwu & Stoffels, 2005), and independent work, including self-instruction (Akinsola & Ifamuyiwa, 2008) and homework (Stols, Kriek & Ogbonnaya, 2008).

Formal presentation is a teacher-centred classroom practice that involves the teacher spending most of the lesson presenting information in a lecture format and/or by using demonstrations. The teacher takes on a role in which the information is presented to the learners without reliance on prepared materials or textbooks. The teacher makes use of SCK to present the information and recitation and application opportunities are typical practices that allow the teacher to informally assess learner understanding (Stols, Kriek & Ogbonnaya, 2008). A second classroom practice that is a balance of learner- and teacher-centred activities is an approach that provides learners with the opportunity to share their problem-solving strategies with one another under the guidance of the teacher. It is commonly referred to as whole class teacher-guided discussion and gives the learners access to a variety of problem-solving strategies whilst the teacher can utilise the interactions for diagnostic and formative assessment. Whole class teacher-guided discussion is beneficial as it provides teachers with opportunities to identify learner misconceptions and to measure the level of understanding within their class. The teachers can then use that information to guide their planning for future lessons (Stols, Kriek & Ogbonnaya, 2008).

Lesson planning is essential in order for teachers to select the best classroom practices for each topic that they teach in the context of their classrooms. Prior planning provides sufficient time for teachers to carefully integrate their SCK with the intended curriculum while utilising their PCK. Lesson plans must allow the teacher the freedom to assess prior knowledge and current understanding, and to address misconceptions, with the goal of covering all of the content in the intended curriculum. However, as recorded by Ono and Ferreira (2010), lessons that address misconceptions seem to be a rare and teachers must use their PCK to guide lessons rather than strictly adhering to prescribed schemes and plans. Lesson planning is essential prior to any practical tasks and gives the teacher time to prepare the equipment, practise the experiments and demonstrations and to make sure that all appropriate safety measure are being taken.

Practical work is a classroom practice that can range from teacher-centred to learner-centred depending on the level of control maintained by the teacher. In many curricula, one of the key features of Science education is that it involves practical work. Practical work can be described as activities in which the learners are able to manipulate and observe real objects and materials (Abrahams & Millar, 2008). It has been reported in literature that the frequency of practical activities in South African Science classes is limited by a lack various factors. Many teachers claim that it is a lack of resources, such as equipment and laboratories and large class sizes, which hamper their ability to do practical work (James & Benson, 2008; Hattingh, Aldous & Rogan, 2007). However, Rogan and Aldous (2005) reported that there is no relationship between the availability of resources and the level of practical work performed. This was supported by case study research in which one particular school had four laboratories, yet did not conduct any practical work. The researchers also commented that in other schools within their case studies, boxes of laboratory equipment and resource kits were found that had never even been unpacked (Hattingh, Aldous & Rogan, 2007). It was concluded that there is no link between the provision of resources and the capacity of teachers and that teachers who are motivated to do practical work will find ways to do so, even in the most poorly resourced schools. Thus, providing schools with equipment and laboratories without proper training is often ineffective (Fricke, et al., 2008; Hattingh, Aldous & Rogan, 2007). The shortage of practical tasks taking place in classrooms is a major area of concern in Science curriculum implementation in South Africa and there is clearly a need for intervention in terms of both resource allocation and professional development. Identifying these individual teachers and providing them with regular practical training within the context of their school environment could be an invaluable form of professional development.

Group work is a form of learning that provides learners with opportunities to discuss and share their problem-solving strategies amongst their peers in a non-threatening environment. Research has shown that peer interaction in this type of setting increases learner achievement (Stols, Kriek & Ogbonnaya, 2008). A subjection of group work that is founded upon the constructivist theory of learning and has shown promise in other countries is cooperative learning (Akinsola & Ifamuyiwa, 2008) which involves learners actively and cooperatively working in small groups towards a common goal. By participating in cooperative learning, learners gain self-confidence, develop compassion towards others and enhance their abilities to work cooperatively to complete tasks (Akinsola & Ifamuyiwa, 2008).

Independent work, including self-instruction and homework, involves learner-centred classroom practices that put the full responsibility and control of learning in the hands of the learner. Self-instruction is a learning strategy in which pre-prepared instructional packages are used by the learners with minimal teacher intervention (Akinsola & Ifamuyiwa, 2008). Homework, on the other hand, is usually comprised of tasks that are an extension of the material that was covered in a recent lesson or those which provide learners with additional opportunities to practice their newly acquired skills (Stols, Kriek & Ogbonnaya, 2008). While it is difficult to assess the extent and benefit of homework, it is a valuable classroom practice in the sense that it provides learners with extension and practice opportunities. Also, it provides teachers with a basis for formative assessment to guide their planning and to provide feedback to their learners.

The classroom practices discussed earlier should overlap with how a teacher assesses learners; by way of either formative and/or summative assessments. Formative and summative assessment strategies are thus also included in the designation of classroom practices. Formative assessment refers to all activities that provide the learners and the teachers with an indication of the extent of learning that has taken place. Formative assessment should be continuous and can take the form of written or verbal feedback on day to day interactions with the subject content. Comments given on homework or feedback during a class discussion would be examples of formative assessment. Whereas, summative assessment is that which contributes to a learner's achievement mark. These assessments are formal and usually occur in the form of portfolio tasks, such as standardised tests, formal practical reports, research projects and examinations. Summative assessments provide an indication of the attained curriculum as a measure of the outcomes of both the intended and implemented curricula. The pinnacle of measuring achievement in the form of a standardised, summative assessment occurs in the form of secondary school exit examinations.

2.5 LEARNER ACHIEVEMENT

Educational research both internationally and nationally has investigated various factors that seem to be significant in influencing learner achievement, including socio-economic status, language, location and teacher quality measures, such as teacher qualifications and classroom practices (Howie, Scherman & Venter, 2008; Gopal & Stears, 2007; Department of Education, 2005; Dekkers & Mnisi, 2003; Darling-Hammond, 2000). The attained curriculum

can be measured by way of learner aspirations and attitudes, learner participation and learner achievement (Howie & Scherman, 2008b) which are the general desired outcomes of Science education in terms of learner interest in Science, Technology, Engineering and Maths (STEM) careers. This circles back to the purpose of globally competitive education in Science. According to the World Science Forum in 2007 "there is a direct correlation between a nation's wealth and its scientific and technological capacity" (James, et al., 2008, p.2). South Africa needs to increase the number of people entering into STEM professions in order to be more globally competitive. To do this, the quality of Physical Science must increase at FET level in order to promote the study of Science at a tertiary level.

Secondary school leaving certificates are a prerequisite for tertiary studies around the globe and serve to indicate the proficiency of a learner in various areas of study. Secondary school exit certifications vary from country to country and are often verified using national benchmarking exams or entrance exams. Popular examples of such Standardised Benchmark exams are the SATs in America and the National Benchmark Test (NBT) in South Africa. The NBT is an assessment for prospective first year entry learners into Higher Education that was designed to measure a writer's levels of proficiency in Academic Literacy, Quantitative Literacy and Mathematics as related to the demands of tertiary study. It assists Higher Education to interpret school-leaving results, such as those of the National Senior Certificate (NSC) (http://www.nbt.ac.za/).

The National Senior Certificate Examination results in South Africa are currently the best measure of a standardised assessment and in the absence of standardised international exit examinations, are used to indicate learner ability for university admissions. However, learners still struggle to cope in University Science Programmes (Fricke, et al., 2008) due to the fact that many of these learners have serious gaps in their content knowledge which hinders their potential in university. These gaps are a result of poor implementation of the intended curriculum, particularly the FET NCS, which is evident in low achievement results at the end of secondary school. As a result, the majority of universities in South Africa have had to adjust to low admission standards as a result of poor learner achievement and have incorporated bridging courses and modified their expectations and level of instruction (Potgieter, Davidowitz & Mathabatha, 2008).

Gopal and Stears (2007) indicate that language and location may be significant determinants of achievement because language, as a result of South Africa's history, is a proxy for other factors which are known to affect educational achievement, such as socio-economic level, education of parents, health of parents and children, school resources, teacher-supply and qualifications (Gopal & Stears, 2007). Poor communities, in particular those of rural Africans, bear the brunt of the past inequalities and continue to be reflected in the national results of the final year examinations in Grade 12 (Howie, Scherman & Venter, 2008). Studies comparing the science achievement of learners from different SES groups in the United States of America show that learners from high-SES groups tend to outperform learners from lower SES groups (Von Secker, 2004) and the same trend can be seen in South Africa, where learners from lower SES groups obtain significantly lower scores than those from higher SES groups (Howie, Scherman & Venter, 2008). Howie, Scherman and Venter found that inexperienced teachers and poorly qualified teachers tend to concentrate in certain geographic areas or schools serving learners of particular socio-economic backgrounds. This finding is supported by the research of Dekkers and Mnisi (2003) and Darling-Hammond (2000) in that poorly qualified teachers tend to be found in less advantaged schools, where conditions are poor and learner achievement results are below average.

Darling-Hammond (2000) reported the following conclusions: "First, while learner demographic characteristics are strongly related to learner outcomes… they are less influential in predicting achievement levels than variables assessing the quality of the teaching force. Second… teacher quality variables appear to be more strongly related to learner achievement than class sizes, overall spending levels, teacher salaries (at least when unadjusted for cost of living differentials), or such factors as the statewide proportion of staff who are teachers. Among variables assessing teacher "quality," the percentage of teachers with full certification and a major in the field is a more powerful predictor of learner achievement than teachers' education levels (e.g., master's degrees)" (Darling-Hammond, 2000, p. 32). Despite all of the previously discussed influences on learner achievement, the problem still persists in that it is widely established that South African learners perform poorly on written standardised tests regardless of whether the tests have been locally or internationally devised (Gopal & Stears, 2007).

2.6 CONCLUSION

In conclusion, the literature review chapter discusses South African and International research which falls in line with the research questions (Section 1.7), and conceptual framework that is presented in Chapter 3, for this study. The literature review served to discuss literature related to the research that has been conducted in the areas of teacher characteristics (Section 2.3), classroom practices (Section 2.4) and learner achievement (Section 2.5). A discussion of two American research studies that offer promising insights with regards to teacher qualification categories and learner achievement, as well as, various professional qualifications and models of teacher education were examined in Section 2.3.1. Section 2.3.2 served to provide an overview of professional development activities and related literature. Following this, additional literature on teacher characteristics was offered in the entitled related experience in Section 2.3.3 and content knowledge in 2.3.4, which was further divided into subject content knowledge (SCK) in Section 2.3.4.1, and pedagogical content knowledge (PCK) in Section 2.3.4.2. Finally, the literature review provided a discussion of recent literature related to classroom practices in Section 2.4 and learner achievement in Section 2.5. The conceptual framework and associated literature will be delivered and discussed as a separate chapter to that of the literature review and can be found in Chapter 3.

CHAPTER 3
CONCEPTUAL FRAMEWORK

3.1 INTRODUCTION

Investigating the interconnection between the previously defined teacher characteristics (Section 2.2); classroom practices (Section 2.3); and learner achievement (Section 2.4); required the exploration of various conceptual models on educational systems. The models that best represent the conceptual framework for this study are presented in Section 3.2. They are grounded in the information processing theoretical approach and are presented in terms of inputs, processes, and outputs. The information processing theoretical approach, or systems theory (Shavelson, 1987) is paralleled with the tripartite model that was developed by the International Association for the Evaluation of Educational Achievement (IEA) which further includes three facets of the curriculum as the intended, implemented and attained curriculum (Kelleghan & Stufflebeam, 2003). The final model that was considered conceptually illustrates the factors related to Science achievement and was developed by Howie (2002) and used by Howie et al. (2008). Following this, the conceptual framework for the secondary data analysis study was presented in Section 3.3 and the constructs were defined and discussed in terms of the related literature.

3.2 CONCEPTUAL MODELS ON EDUCATIONAL SYSTEMS

Howie (2002) incorporated Shavelson's (1987) systems theory which utilises an information processing with the IEA's tripartite model (Kelleghan & Stufflebeam, 2003). The information processing theoretical approach to educational systems has been exemplified in the systems theory (Shavelson, 1987) and is illustrated in Figure 3.1 in terms of inputs, processes and outputs. It can be paralleled with the IEA tripartite model which includes three aspects of the curriculum as the intended, implemented and attained curriculum (Kelleghan & Stufflebeam, 2003).

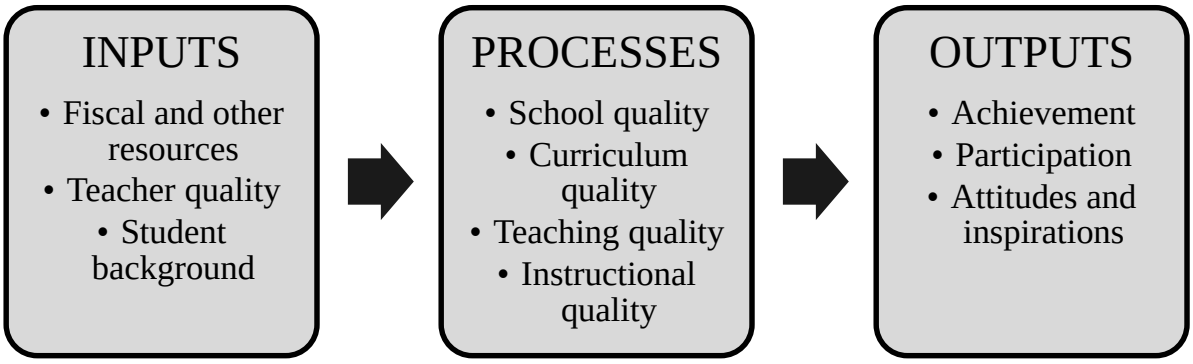

Figure 3.1 - The components of an educational system. (Shavelson, 1987, p.6)

The IEA tripartite model divides the curriculum into three categories based on system level, assessment features and curriculum appearance (IEA, 1998). The curriculum categories are the intended curriculum, the implemented curriculum and the attained curriculum. The intended curriculum can be defined as what the community values and occurs at a national or macro system level (Reddy, 2006). It can be further defined to be that which is specified in official curriculum statements and stipulates what learners are expected to learn (Kelleghan & Stufflebeam, 2003). For the purposes of this research, the intended curriculum is that which has been specified by the Gauteng Department of Education in the National Curriculum Statement for Grades 12 Physical Science (DoE, 2005). The implemented curriculum is what and how the teachers and school teach and is viewed at a meso system level. Curriculum implementation includes all of the classroom practices that inform learning as discussed and defined in the literature review. The attained curriculum occurs at a micro system level and has to do with what learners actually learn and is best reflected in learner achievement (as discussed previously in the literature review) (Reddy, 2006; Kelleghan & Stufflebeam, 2003). For the purposes of South African FET achievement, the best measure of learner achievement is the results of the NSC examinations for Grade 12. The rational for this measure has been defined and explained in the literature review. Howie's (2002) combination and extension of these two models was used more recently by Howie and Scherman (2008) which will now be discussed, followed by how these three educational models have been assimilated into the conceptual framework for this secondary data analysis research project.

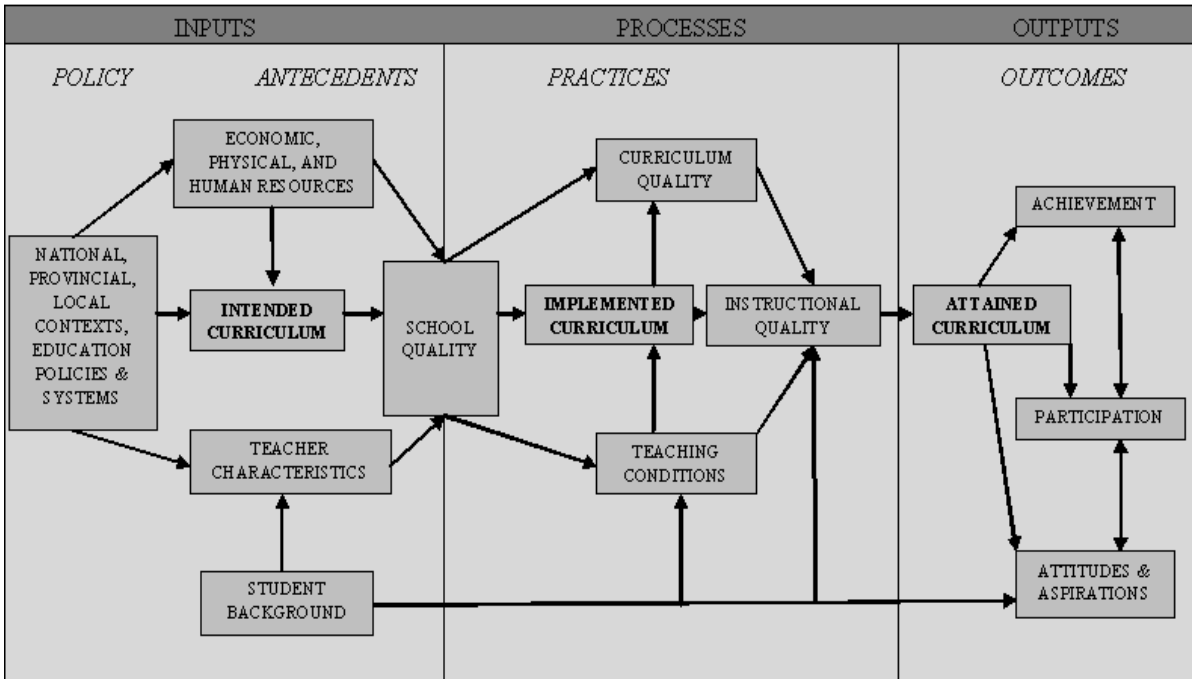

Figure 3.2 - Factors related to Science achievement (Howie & Scherman, 2008b, p.128)

Howie and Scherman's (2008b) model can be unpacked to include various concepts and constructs that are influential to Science achievement. It is important to note that the conceptual framework for this model was the same as for the TIMSS 1999 project (Howie & Scherman, 2008b). The general constructs of their model can be classified into inputs, processes and outputs. The inputs are further separated into policies and antecedents where the constructs incorporated as inputs are: national, provincial, local contexts, education policies and systems; economic, physical and human resources; teacher characteristics; learner background. The constructs related to processes parallel with practices, specifically, instructional quality, teaching conditions and curriculum quality. Finally, the outputs of the system relate to outcomes and contain the constructs achievement, participation, attitudes and aspirations. It can also be noted that the curriculum components of the tripartite model have been included in this model, specifically, the intended, implemented and attained curriculum as defined previously. The relationships between the constructs illustrated in Howie and Scherman's (2008b) model will be exemplified in the following paragraphs.

As interpreted from Figure 3.2, the construct national, provincial, local contexts, education policies and systems serves to influence the construct economic, physical and human resources; teacher characteristics; and intended curriculum. The construct student background influences both teacher characteristics and the attitudes and inspirations of the learners. According to Howie and Scherman (2008b), the construct teacher characteristics included: age, gender, race,

language, highest qualification, field of specialization, and years of experience. Of these characteristics, Howie and Scherman (2008b) reported that only the factors for highest qualification and teachers' home language, in the overall sample set resulted in statistically significant findings with a positive relationship between highest qualifications and the teachers' home language with science achievement (Howie & Scherman, 2008b). Despite the documented findings on teacher's home language, I have not chosen to investigate its influence on Science achievement as it does not link directly with the research questions and purpose for this study. This decision is supported in literature by "Quantitative analyses [which] indicate that measures of teacher preparation and certification are by far the strongest correlates of student achievement in reading and mathematics, both before and after controlling for student poverty and language status" (Darling-Hammond, 2000, p.1). Thus, the focus of this study and its research questions is rather on the interconnection between teacher qualifications, classroom practices and learner achievement. It is for this reason that these have been included in the conceptual framework for my secondary data analysis research project. The contextual components can all be recognised as influential; however, they are beyond the realm of Masters research, and thus included in the perimeter of my conceptual framework.

The constructs related to processes parallel with practices, specifically, instructional quality, teaching conditions and curriculum quality. Curriculum quality as defined by Howie and Scherman (2008b) includes teacher-related, and learner-related, obstacles that inhibit the teacher's ability to teach. They further specified that learner-related factors include: "students with different academic abilities, students with a wide range of backgrounds, students with special needs, uninterested students, disruptive students, low morale amongst students and threats to students' safety. The teaching factors include: shortages of computer hardware, computer software, instructional equipment, inadequate facilities, a high student to teacher ratio and a low morale amongst the teaching staff" (Howie & Scherman, 2008b, p.123). For the purposes of my research, curriculum quality (as defined above) has been included in the perimeter of my framework as a component of context. The motivation for doing so is based on the reality that these constructs are precursors or influences on classrooms practices; however, for the purpose of a Masters dissertation it is not practical to research these components. It is important to reiterate, as stated in the introduction and literature review, that it is impossible to separate educational research from contextual factors. According to Howie and Scherman (2008b), the concept teaching conditions includes class size, teaching load, teachers' dedication and perceptions. Class size and teaching load form components of context

that will receive little attention in my research as explained previously; however, teachers' dedication and perceptions have been recognized as teacher characteristics and incorporated as such for the purposes of my research, as discussed in the literature review. In Howie and Scherman's (2008b) model, instructional quality comprises the proportion of first language pupils in the science class, the teaching style of science teachers and teachers' beliefs. It has already been researched significantly that language has significant relationships with learner achievement; however, language of instruction and home language have not been included for the purposes of my research and have been omitted in my conceptual framework. The teaching style of science teachers and teachers' beliefs have been included in the constructs classroom practices and teacher characteristics, respectively, in my framework as indicated in the literature review. With regard to teaching conditions and resources, only the total teaching time and the proportion of the pupils in the class who spoke the medium of instruction as their first language at home were found to be related to science achievement. Thus, total teaching time forms a component of the construct classroom practices in my conceptual framework and language is recognised as an influential contextual component.

The outputs of the education system relate to outcomes and contain the constructs achievement, participation, attitudes and aspirations (Howie & Scherman, 2008b). Learner achievement also depends on the social and educational context, and on learner characteristics, such as, ability, attitude, interests, and effort (Martin, et al., 2000). It is a recommendation for further research to look more closely at the constructs of participation, attitudes and aspirations; however, these will not be investigated in the secondary data analysis. For the purposes of my research, the construct learner achievement will be measured by the NSC examination results (as discussed in the literature review).

3.3 CONCEPTUAL FRAMEWORK

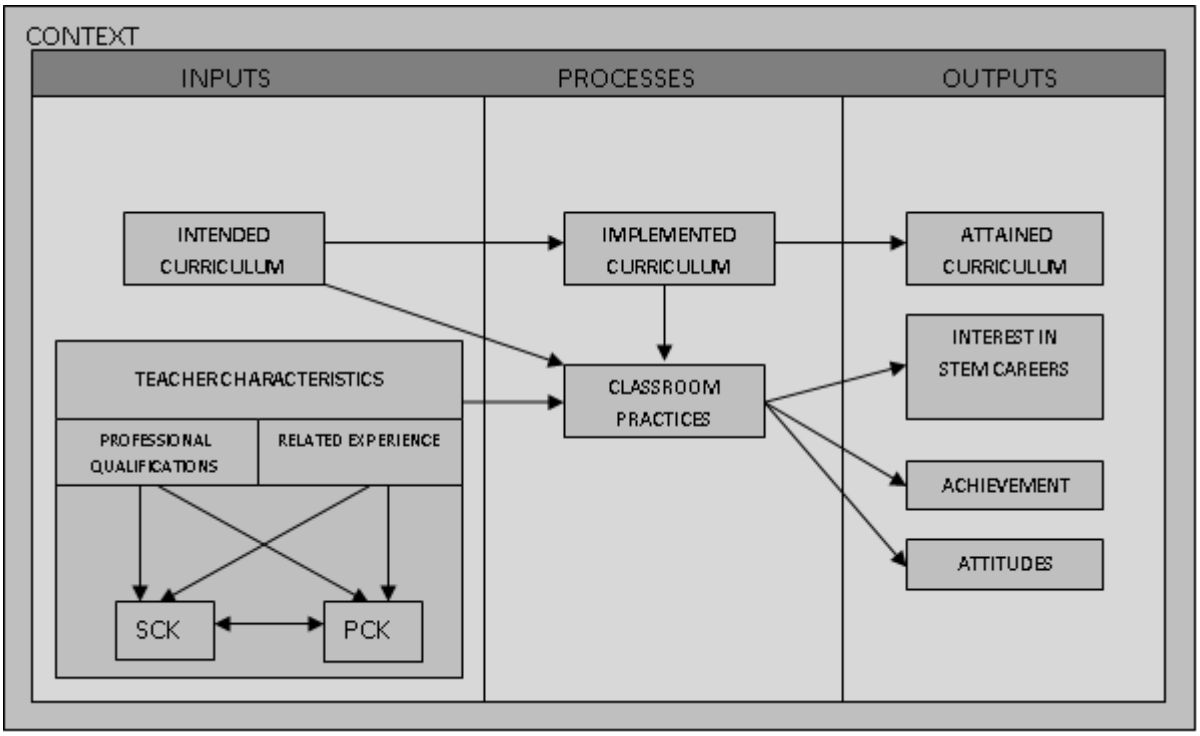

Figure 3.3 - Conceptual framework for this study to investigate the interconnection of teacher characteristics, classroom practices and learner achievement in Science (modified from Howie & Scherman, 2008b, p.128).

The key concepts within the above framework have been defined in Chapter 1 and have been included again in this section for the purpose of increased clarity. Teacher characteristics can be defined as: teacher qualifications (Bolyard & Moyer-Packenham 2008; LaTurner, 2002; Darling-Hammond, 2000); related experience (James & Benson, 2008; Onwu, 2000); subject content knowledge (SCK) and pedagogical content knowledge (PCK) (Adler, et al., 2009; Beets, 2009; van Dijk & Kattmann, 2007). Classroom practices can be defined as all of the activities and learning strategies that teachers use in their lessons. Learner achievement in terms of this research refers to the performance of Grade 12 Physical Science learners on the 2009 National Senior Certificate Examinations.

In my conceptual framework, I have included the intended curriculum and teacher characteristics as inputs. Teacher characteristics, such as experience, professional qualifications, personal beliefs, PCK and SCK influence how a teacher will interpret the intended curriculum. The intended curriculum is what needs to be taught and for the purposes of this research, is in the form of the NCS for Grade 12 Physical Science. Returning to the issue of inputs, comprehensive qualifications, experience and a clear national curriculum statement NCS are similar to a good recipe with thorough instructions. It gives the teacher guidance to

work from until they have acquired enough practice and experience to modify it as they choose. The same applies to the South African education system.

Both the intended curriculum and teacher characteristics will influence the processes, specifically, the construct classroom practices (Martin et al., 2000). These classroom practices, as defined previously, refer to the implemented curriculum which is what is taught. The classroom practices will in turn influence the attained curriculum which is what the learners actually learn. Learner achievement also depends on the social and educational context, and on learner characteristics, such as, ability, attitude, interests, and effort (Martin et al., 2000). For the purposes of my research, the construct learner achievement will be measured by the NSC examination results (as discussed in the literature review).

Context has been included in the outer boundary of the framework. The reason that I decided to place it in this location is because I believe that the entire system (inputs, processes, and outputs) is strongly influenced the context of the country, teachers, learners and the school. A significant amount of research has been conducted on the effects of South African context with regards to all areas of my framework (Howie, Scherman & Venter, 2008; James & Benson, 2008; Gopal & Stears, 2007; Onwu & Stoffels, 2005; Johnson, et al., 2003, 2000; Onwu, 2000), many of which indicate that it is impossible to separate curriculum implementation from context. While it is essential to look at the two in conjunction, I will be acknowledging this and will exclude it due to the limited scope of a Masters study.

The inputs of my framework centralise around teacher characteristics. Teacher characteristics can be defined as the professional background of the teacher (qualifications) (Bolyard & Moyer-Packenham, 2008; LaTurner, 2002; Darling-Hammond, 2000); related experience (James & Benson, 2008; Onwu, 2000); subject content knowledge (SCK) and pedagogical content knowledge (PCK) (Adler, et al., 2009; Beets, 2009; van Dijk & Kattmann, 2007). Bolyard & Moyer-Packenham (2008) also chose to include teacher behaviours, practices, and beliefs as aspects of Science teacher quality characteristic, however, teacher beliefs will not be investigated in this particular research study.

The core of the outputs section of the framework is the attained curriculum in terms of learner achievement. The extent of the attained curriculum will be assessed by way of the Grade 12 Senior Certificate examinations results for Physical Science. The attained curriculum can also

be expanded to include learner attitudes and aspirations which will affect their interest in Science, technology, engineering and Maths (STEM) careers, however, this was not part the research questions and as such learner attitudes and aspirations will not be analysed. The choice to not analyse these components is justified by research findings from Howie and Scherman (2008b) that verified that many learners in South Africa have interest in STEM careers; however, they do not have the achievement results to pursue them.

It is true that South Africa needs to increase the number of people entering into STEM professions in order to be more globally competitive. But to do this, the quality of Physical Science must increase at a FET level in order to promote the successful study of Science at a tertiary level. Currently, FET learners are significantly underprepared for University level Science and this can be attributed in part to the fact that South Africa has a shortage of well-qualified Science teachers (Potgieter, Davidowitz, & Mathabatha, 2008).

3.4 CONCLUSION

This chapter served to explore the existing models that have been identified as good representations of the constructs for the conceptual framework for this study, these were presented in Section 3.2. The models that were selected are grounded in the information processing theoretical approach and are presented in terms of inputs, processes, and outputs. The information processing theoretical approach, or systems theory (Shavelson, 1987), was paralleled with the tripartite model that was developed by the International Association for the Evaluation of Educational Achievement (IEA) which further includes three facets of the curriculum as the intended, implemented and attained curriculum (Kelleghan & Stufflebeam, 2003). The final model that was considered conceptually illustrates the factors related to Science achievement and was developed by Howie (2002) and used by Howie et al. (2008). Following this, the conceptual framework for the secondary data analysis study was presented in Section 3.3 and the constructs were defined and discussed in terms of the related literature. The next chapter, Chapter 4, discusses the research methodology for this secondary data analysis study on the interconnection between teacher qualifications, classroom practices and learner achievement in FET Science at a Grade 12 level. The research methodology serves to investigate the research questions in relation to the conceptual framework as discussed in Chapter 3. This study, a mixed methods secondary data analysis, utilises both quantitative (quan) and qualitative (QUAL) methodologies to best investigate the research questions.

CHAPTER 4
RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

The research methodology is conferred in this chapter and begins with a discussion of the research design in Section 4.2 where the paradigm of pragmatism is discussed in relation to the chosen mixed methods research design. The mixed methods research design is further conversed in Section 4.3 and entitled research methodology. This is followed by a summary of the sample methods found in Section 4.4 which encapsulates the procedures that were used for the 18 different schools in the evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools project (CEA, 2010); and the sample methods for the secondary analysis. Section 4.5 describes the instruments that were used in the primary study and in the secondary analysis (see Appendix A). The data collection and research procedures can be found in Section 4.6, followed by details regarding the data analysis in Section 4.7. Finally, a discussion of methodological norms occurs in Section 4.8 and the ethical considerations in Section 4.9. Section 4.10 presents some of the limitations of the secondary analysis. Whilst reading this chapter, one will notice that the research design and methods have been selected with consideration of the literature review in order to answer the research questions in line with the conceptual framework of the secondary analysis.

The main research question for the secondary analysis is: *What is the interconnection between Grade 12 Physical Science teacher characteristics, classroom practices, and National Senior Certificate Examination results in Gauteng secondary schools?* From the main research question, the following sub-questions can be identified: What are the different categories of teacher characteristics in the FET study sample population? What are the various classroom practices that are used by teachers in each of the categories of teacher characteristics? To what extent are the 2009 Grade 12 National Senior Certificate Examination results related to teacher characteristics and classroom practices? In order to best address these research questions, a mixed method approach will be used. The details of this approach are discussed in Section 4.2.

The project data used for the secondary analysis is taken from the “Evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools”. This project was conducted by the Centre for

Evaluation and Assessment (CEA) at the University of Pretoria on behalf of the Gauteng Department of Education (GDE) and ran from November 2008 to February 2010 with the aim of evaluating FET Mathematics and Physical Science curriculum implementation in Gauteng schools. The overall project design consisted of in-depth case studies of 18 schools across five quintiles of education in eight districts (CEA, 2010).

The secondary analysis of the data involves the analysis of Science teacher questionnaires, teacher interviews, lesson observations, and final 2009 Grade 12 National Senior Certificate Examination results, in terms of pass rates. This data is used in order to address the inputs, processes and outputs of the study as described in the conceptual framework and literature review. The use of the three different instruments (quantitative and qualitative) provides a detailed description of the categories of teacher characteristics that can be associated with different types of classroom practices. The data can also be used in order to identify the frequency of each teacher characteristic in the sample population. This data can then be associated with the Grade 12 exam pass rates that occurred per school and interconnected with classroom practices within that school in the case study analysis. In order to do this, a multi-phased study was necessary that involved a sequence of four day-long visits to each school over three phases and the course of one academic school year (specifically, 2009). In order to realise the research objectives, a pragmatist viewpoint has been taken and as such a mixed methods design has been selected using both qualitative and quantitative data and analysis methods.

4.2 RESEARCH DESIGN

Pragmatism is a worldview, sometimes also referred to as a paradigm, which is associated with a mixed methods research design (Lund, 2012; Johnson & Onwuegbuzie, 2004). From a pragmatist perspective, the researcher gives central priority to the research problem and then uses whatever methods are necessary to best investigate the problem (Creswell & Plano Clark, 2007, p. 23). By using both quantitative and qualitative methods, the respective strengths can be utilised and respective weaknesses escaped (Lund, 2012; Johnson & Onwuegbuzie, 2004; Tashakkori & Teddlie, 1998). The pragmatist uses a combination of quantitative and qualitative methods and mixes them in various ways to best answer the research question (Johnson & Onwuegbuzie, 2004). The quantitative and qualitative methods may be used concurrently or sequentially; one approach might be weighted more strongly than the other; and the integration can be comprehensive or restricted (Lund, 2012). Mixed methods has been used in basic and

applied research, especially in the field of evaluation research (Lund, 2012), which is the field of study for this masters research in Assessment and Quality Assurance (AQA). Researchers with a pragmatic worldview will exhibit singular and multiple realities throughout data collection and analysis. They will shift between generating and testing a hypothesis (quantitative) and generating themes (qualitative), they will engage in both subjective and objective analysis of the data (Lund, 2012). The views of the researcher therefore play a role in the interpretation and the researcher may choose to report formally or informally on their findings (Creswell & Plano Clark, 2007).

4.3 RESEARCH METHODOLOGY

A mixed-methods research design has been selected to answer the main research question because it fits the pragmatic stance, specifically, to identify the interconnection between teacher characteristics (such as, formal qualifications, experience, and knowledge), classroom practices and learner achievement. A concurrent mixed methods design was used for the secondary data analysis. Specifically, quantitative and qualitative data were collected and used in conjunction to provide a detailed description and to best understand the research problem (Creswell & Plano Clark, 2012; Lund, 2012). However, the qualitative data took priority (QUAL + quan) illustrated by the notion. The '+" sign indicates that the secondary analysis will be a concurrent design which was also the case for 'the evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools' project (CEA, 2010).

Since data collection was completed in 2009, the quantitative and qualitative data were analysed concurrently for the secondary analysis study. Both quantitative, specifically, science teacher questionnaires and science teacher interviews, and qualitative data, such as written classroom observations, were used to analyse teacher qualifications and experience. This provided an indication of themes that were analysed and a modified version of LaTurner's (2002) classification scheme was used to develop categories of teacher characteristics for South African secondary Science teachers. This categorisation scheme was then used to interconnect teacher characteristics with qualitative classroom practices and later the quantitative pass rates for the 2009 Grade 12 learners that were taught by each teacher. It is important to recall that the purpose of the classification scheme was not to 'label' individuals or school, but served a function to better understand and serve the needs each school and its teachers; possibly to inform INSET and other interventions at the learning and instruction levels (Rogan & Grayson,

2003). Qualitative data was collected in the form of teacher interviews and classroom observations in order to provide thick, rich descriptions about various teacher characteristics and classroom practices. These interviews and observations were coded and the frequency of each type of code was used in conjunction with the descriptions. Quantitative analysis were done using the 2009 Grade 12 National Senior Certificate Examination pass rates for each school or teacher and was interconnected with the other constructs that were presented in the framework.

The rationale for using a mixed method design is justified by the combination of both quantitative and qualitative data to provide a more complete picture by exploring trends and generalizations and acquiring rich, thick descriptions to increase trustworthiness (Creswell & Plano Clark, 2007). This is useful because quantitative data provides an opportunity to look at numerous Grade 12 teachers with regards to their qualifications and the achievement results obtained by the learners they teach. It also allows a detailed exploration of the various types of classroom practices that are used by these teachers through the personal account of the teachers in teacher interviews and through the lesson observations of these teachers. Data analysis methods were used to categorise responses in questionnaires and interviews both quantitatively and qualitatively by looking at frequencies and trends. The extent to which relationships occur between teacher characteristics, classroom practices and achievement were analysed in terms of correlations. As such, a concurrent mixed methods design was most fitting to address the research questions using both quantitative and qualitative data collection and analysis using the procedures outlined in Table 4.1. Finally, case studies will be presented as narratives in Chapter 6 for four of the teachers who possess unique teacher characteristics or classroom practices to further exemplify the interconnections.

Table 4.1 - Mixed methods data source collection and data analysis with reference to research questions.

Research Question	Data Source	Data Analysis
1. What are the different categories of teacher characteristics in the FET study sample population?	Quantitative questionnaires; and Qualitative teacher interviews	Descriptive statistical analysis Content analysis
2. What are the various classroom practices that are used by teachers in each of the categories of teacher characteristics?	Qualitative data by way of teacher interviews and classroom lesson observations	Content analysis
3. To what extent are the 2009 Grade 12 National Senior Certificate Examination results related to teacher characteristics and classroom practices?	Quantitative Grade 12 final results in terms of overall pass rate per teacher; and Quantitative Science teacher questionnaires	Descriptive statistical analysis and Pearson correlation coefficients
4. What are the interconnections between Grade 12 Physical Science teacher characteristics, classroom practices, and learner achievement in Gauteng secondary schools?	Categories of teacher characteristics; categories of classroom practices; average pass rate per school for NCS Physical Science.	Correlations Content analysis

Categories of teacher qualification (Table 4.2) have been defined for this secondary analysis in order to facilitate comparisons between teacher qualifications and learner achievement in South Africa. These categories have intentionally neglected to include the post-graduate specialties at masters and doctorate level and have been modified from those previously utilised in LaTurner's (2002) study in the United States of America. The rational for not including categories on post-graduate degrees stems from reported literature that was discussed in Chapter 2 with regards to findings that suggest that a full teacher certification and a major in the field is a more powerful predictor of learner achievement than teachers' acquisition of higher degrees (Darling-Hammond, 2000).

Table 4.2- Categories of teacher qualifications (adapted from LaTurner, 2002, p. 656)

Categories of Teacher Qualifications for South Africa FET Physical Science				
Postgraduate Degree or Certificate in Education	**Teaching Diploma**	**Non-teaching Specialist Qualification Only**	**Unsuitable Teacher Qualification**	**Non-qualified**
These are teachers who have a postgraduate teaching certificate from a university/technikon -PGCE; or -HED	Teachers with a diploma in higher education obtained from a college -Secondary Education Diploma (3 or 4 year) -Further Diploma of Education -Advanced Certificate of Education (ACE)	Teachers who are not formally qualified teachers but possess significant experience or Science specialisation -B.Sc. or equivalent	Teachers without phase appropriate teaching qualifications -Junior Primary Teacher Certificate (JPTC) -Senior Primary Teacher Certificate (SPTC)	Teachers who do not possess a teacher qualification, B.Sc. or equivalent diploma or certification

A recommendation for further research has been included in Chapter 6 suggesting that these categories can be cross-referenced with both SAQA and SACE data. The data in the primary study was all self-reported and should be validated by concrete certificates in future studies. It is important to note that teachers having qualifications in non-Science areas are categorised as either “non-qualified” or “non-specialist teaching qualified only”, this data was not attainable in the primary study and is also a recommendation for future research.

Two viable instruments that have been used previously in research involving classroom practices are the Science Lesson Observation System (SLOS) (Gwimbi and Monk, 2005) and the profile of implementation (Rogan and Grayson, 2003). Gwimbi and Monk (2003) reported on the use of the Science Lesson Observation System (SLOS) as an effective tool to capture qualitative data on classroom practices, such as, classroom organisation, lesson activities, teacher-learner interactions, and the learner-centeredness of lessons. A second instrument that has been used previously to assess classroom practices and curriculum implementation was formulated by Rogan and Grayson (2003). The framework that they devised is specific for the context of schools in developing nations and thus contextually suitable for the majority of classrooms within South Africa. This model was used in a school-based programme in Mpumalanga to identify factors that impact on curriculum implementation (Rogan & Aldous, 2005; Rogan, 2005). Rogan and Grayson’s (2003) profile of implementation provides four clear levels to classify classroom practices (see Table 4.3). In the profile of implementation,

teacher's classroom practices should be viewed in terms of how well they enrich the experiences of their learners (Rogan & Grayson, 2003).

Table 4.3 - Profile of implementation contextualized for the natural Science learning area of C2005 (Rogan & Grayson, 2003, p. 1183).

Level	*Classroom interaction*	*Science Practical Work*	*Science in Society*	*Assessment*
1	***Teacher:*** Presents content in a well organised, correct and well sequenced manner, based on a well-designed lesson plan. Provides adequate notes. Uses textbook effectively. Engages learners with questions. ***Learners:*** Stay attentive and engaged. Respond to and initiate questions.	Teacher uses classroom demonstrations to help develop concepts. Teacher uses specimens found in the local environment to illustrate lessons.	Teacher uses examples and applications from everyday life to illustrate scientific concepts. Learners ask questions about Science in the context of everyday life.	Written tests are given that cover the topic adequately. While most questions are of the recall type, some require higher order thinking. Tests are marked and returned promptly.
2	***Teacher:*** Textbooks are used along with other resources. Engages learners with questions that encourage in-depth thinking. ***Learners:*** Use additional (to text book) sources of information in compiling notes. Engage in meaningful group work. Make own notes on the concepts learned from doing these activities.	Teacher uses demonstrations to promote a limited form of inquiry. Some learners assist in planning and performing the demonstrations. Learners participate in closed (cook-book) practical work. Learners communicate data using graphs and tables.	Teacher bases a lesson (or lessons) on a specific problem or issue faced by the local community. Teacher assists learners to explore the explanations of scientific phenomena by different cultural groups.	Written tests include at least 50% of the questions that require comprehension, application and analysis. Some of the questions are based on practical work.
3	***Teacher:*** Probes learners' prior knowledge. Structures learning activities along 'good practice' lines (knowledge is constructed, is relevant, and is based on problem solving techniques). Introduces learners to the evolving nature of scientific knowledge. ***Learners:*** Engage in minds-on learning activities. Make own notes on the concepts learned from doing these activities.	Learners perform 'guided discovery' type practical work in small groups, engaging in hands-on activities. Learners can write a scientific report in which they can justify their conclusions in terms of the data collected. Teacher designs practical work in such a way as to encourage learner discovery of information.	Learners actively investigate the application of Science and technology in their own environment, mainly by means of data gathering methods such as surveys. Examples here might include an audit of energy use or career opportunities that require a scientific background.	Written tests include questions based on seen or unseen 'guided discovery' type activities. Assessment is based on more than written tests. Other forms of assessment might include: reports on activities undertaken; creation of charts and improvised apparatus; reports on extra reading assignments.

Level	*Classroom interaction*	*Science Practical Work*	*Science in Society*	*Assessment*
4	***Teacher:*** Facilitates learners as they design and undertake long-term investigations and projects. Assists learners to weigh up the merits of different theories that attempt to explain the same phenomena. ***Learners:*** Take major responsibility for their own learning; partake in the planning and assessment of their own learning. Undertake long term and community-based investigations projects.	Learners design and do their own 'open' investigations. They reflect on the quality of the design and collected data, and make improvements. Learners can interpret data in support of competing theories or explanations.	Learners actively undertake a project in their local community in which they apply Science to tackle a specific problem or to meet a specific need. An example might be on growing a new type of crop to increase the income of the community. Learners explore the long term effects of community projects. For example, a project may have a short-term benefit but result in long term detrimental effects.	Performance on open investigations and community based projects are included in the final assessment. Learners create portfolios to represent their 'best' work.

Rogan (2006) argues that a school is only able to implement changes, which are within the school's Zone of Feasible Implementation, a concept which draws on Vygotsky's (1978) notion of the Zone of Proximal Development. The value of this theoretical framework is that it provides a tool for studying curriculum change across a range of contexts within the South African education system. While Rogan and his colleagues' (2003; 2005; 2006) research is not specifically about teacher education, it does provide support that teacher learning, behaviours and beliefs should be looked at in the context of educational reforms (Adler et al., 2009; Johnson, Scholtz, Botha & Hodges, 2003) and used to inform teacher education and professional development.

Teacher characteristics, as previously defined in Chapter 1, contribute to classroom practices and how the curriculum is implemented. The way in which a teacher teaches a particular group of learners is thought to influence the outcomes and learner achievement. It is significant to study lesson structure, teacher presentation, learner involvement, resource use, in an attempt to make links with the various categories of teacher characteristics. Abrahams & Millar (2008) found that most teachers with subject specialisation did not rigorously follow schemes, textbooks or set worksheets but rather used a variety of resources and strategies. Hacker and Rowe (1985 in Abrahams and Millar, 2008) said that 'teachers working outside of their specialist subject tend to rely more on routine and controllable activities which reduce the likelihood of unexpected events and questions'. During teacher observations, it would be useful to note what qualifications teachers have with how heavily they rely on textbooks and schemes

of work and which teachers refer regularly to the NCS and use a variety of resources and strategies. Pre-OBE and pre-NCS teaching in South Africa supported the strategy of following a set scheme but this is no longer the most effective method of teaching. Teachers must use formative assessment strategies to guide their teaching and encourage learners to explore and question.

A shortfall of using Rogan and Grayson's (2003) profile of implementation for this secondary analysis is that it was contextualised for natural Science as a junior college level, rather than for Physical Science at a FET level. Also, Rogan and Grayson's (2003) profile of implementation does not address teachers who are 'implementing' below the standard of Level 1 in Table 4.1, as illustrated previously. Thus, there was a need to use the Science Lesson Observation System (SLOS) (Gwimbi & Monk, 2003) and Rogan and Grayson's (2003) profile of implementation, in order to better evaluate the classroom practices that relate to FET Physical Science. The modified profile of implementation (Rogan and Grayson, 2003) and the SLOS (Gwimbi & Monk, 2003) were used in conjunction to generate the analysis codes for classroom practices with regards to teacher presentation, teacher involvement, learner involvement and resource use. The SLOS criteria were originally developed and utilised in a Zimbabwean study on classroom practices and context in high school Biology. It was also useful in informing codes for the qualitative analysis. The list was used in a checklist form where observers ticked the related components every minute on the minute for the duration of the lesson (Gwimbi & Monk, 2003) and is presented in a modified format in Table 4.4. According to Gwimbi and Monk (2003, p.207), "in theory lessons, teachers from the self-perceived better resourced schools were observed to use less individual organisation, less written exercises, more whole class organisation, and more listening to the teacher than to the teachers in the poorer schools. In practical lessons teachers in the better self-perceived better resourced schools were observed to use less whole class organisation, less small group organisation, more individual organisation, less listening to teacher, less teacher explanation, less teacher questioning, and to conduct more practicals".

Table 4.4 – A modified account of 'The Science Lesson Observation Schedule' (Gwimbi & Monk, 2003)

Lesson Structure/ Grouping:	Learner Activities:	Teacher-learner Interactions:
• Whole class activity • Small group activity • Individual activity	• Listening to input from teacher • Observing demonstration • Copying • Reading • Writing answers to exercises • Preparing or clearing away • Conducting practical work • Creative writing or drawing • Listening to feedback from pupils • Discussing (active conversation)	• Instructions from teacher • Explanation (content) from teacher • Teacher led questioning • Pupil led input (feedback) • Pupil led questions • Teacher passive

4.4 SAMPLE

4.4.1 Sample Selection for the Primary Study

The original sample was selected for the 'evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools' project that was conducted by the Centre for Evaluation and Assessment (CEA) at the University of Pretoria on behalf of the Gauteng Department of Education (GDE). The sample of 18 secondary schools was stratified (by District and Quintile) and randomly selected, based on the available budget. The selection and nature of the sample was discussed and finalised during the first phase of the project in conjunction with the project management teams from both the Joint Education Trust (JET) and the GDE. The original study was designed in such a way that all the FET teachers of Mathematics and Physical Science from the selected schools were tracked as cases across three data collection phases to measure the extent of curriculum implementation and classroom practice for FET Mathematics and Physical Science classrooms (FET main report).

4.4.2 Sample Selection for the Secondary Data Analysis

Using the "Evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools" project sample as the population for my research, I used a purposive sampling procedure. Only the Grade 12 Physical Science data from the 18 schools was used. From this data selection, the schools were sorted based on the completeness of the data sets and the extent of their participation in the

study. Their participation in all phases is ideal; however, if the teacher remained teaching at the school, regardless of project participation in the three phases of data collection, they were included in the sample data set. Only teachers who completed the Science teacher questionnaire, participated in at least one teacher interview and one classroom observation were be selected for the case studies. Additionally, all of the teachers who completed the Science teacher questionnaire were included in the correlation analysis to identify the extent to which relationships exist between various teacher characteristics, classroom practices and learner achievement.

Table 4.5 illustrates the data that was available for the secondary analysis using the selection criteria stated in the previous paragraph. This resulted in Science 18 teachers for 13 different schools across the 5 quintiles for multiple districts. From this, several teacher profiles were found to have incomplete datasets. For example, School 3, TS3 was not further analysed and the rationale for omission was due to a missing Science teacher questionnaire. Thus, it was not possible to identify this teacher's qualifications or years of experience. Both of the Science teachers from School 6 were not selected for the secondary analysis and the rationale for omission was due to missing Phase I and Phase II observations for TS2. TS1 was omitted due to the difficulty in associating NCS results with teacher as there were two Grade 12 Physical Science teachers. Both of the Science teachers from School 8 were omitted from the secondary analysis because of the missing Science Teacher Questionnaire for TS3 which made it not possible to identify qualifications. TS1 was omitted due to the difficulty in associating NCS results with a specific Science teacher as there were two Grade 12 Physical Science teachers. The teachers for School 12 were omitted from the secondary analysis as they did not participate in the Phase I observations. This was relevant rationale because all of the other teachers that were selected participated in the Phase I observations which contained the criteria that best related to the research questions in terms of classroom practices. The Science teacher for School 13 was not selected for the secondary analysis because only Grade 10 lessons were observed by the fieldworker, no Grade 12 observations were done. Thus, the data did not relate to the research questions. Finally, School 17 was not included in the secondary analysis because there was a missing Science Teacher Questionnaire for TS3 which made it not possible to identify that teacher's qualifications. TS1 and TS2 omitted due to the difficulty involved in associating NCS results with a specific Science teacher as there were three Grade 12 Physical Science teachers. All of these criteria are visible in the Table 4.5 below.

Table 4.5 – The selection criteria that was used for selecting participants for the secondary data analysis.

Secondary Analysis - Participant Selection Criteria											
Qualitative Data Selection for Secondary Data Analysis	**School Codes**	**Science Teacher Codes**	**Qualification Data from Science Teacher Questionnaires**					**Additional Data Available**			
								Interviews		**Observations**	
			Highest Level of Formal Education	**Teaching Diploma/ Certificate**	**Type of Diploma/ Certificate**	**Teaching Experience altogether (Total years)**	**Physical Science Teaching Experience (Years)**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
P1-SCH2-TS1-I P1-SCH2-TS1-OB	2	TS1	Finished degree or diploma	No	N/A	18	18	Yes	Yes	Yes	No
P1-SCH3-TS3-I P1-SCH3-TS3-OB	3	TS3	Not available					No	N/A	18	18
P1-SCH4-TS2-I P1-SCH4-TS2-OB	4	TS2	Finished degree or diploma	Yes	HED	40	40	Yes	Yes	Yes	Yes
P1-SCH5-TS2-I P1-SCH5-TS2-OB	5	TS2	Finished degree or diploma	Yes	Other	17	8	Yes	Yes	Yes	Yes
Rationale for omission: *Missing Phase I observation for TS2 and PI and PII data so not possible to identify classroom practices, TS1 omitted due to difficulty in associating NCS results with teacher as two Grade 12 Physical Science teachers.*	6	TS1	Finished post graduate degree	Yes	Secondary Education Diploma	18	18	Yes	Yes	Yes	Yes
	6	TS2	Finished post graduate degree	Yes	PGCE	16	16	Yes	No	No	No
Rationale for omission: *Missing Science Teacher Questionnaire for TS3 so not possible to identify qualifications, TS1 omitted due to difficulty in associating NCS results with teacher as two Grade 12 Physical Science teachers.*	8	TS2	Finished degree or diploma	Yes	3-year College of Education Diploma	7	5	Yes	Yes	Yes	No
	8	TS3	Not available					Yes	Yes	No	Yes
P1-SCH9-TS1-I P1-SCH9-TS1-OB	9	TS1	Finished post graduate degree	Yes	HED	7	7	Yes	Yes	Yes	Yes
Rationale for omission: *Both TS1 and TS2 did not participate in phase 1 observations. For the purpose of consistency, they were not included in the secondary analysis for this reason.*	12	TS1	Omitted	Yes	Omitted	12	12	Yes	Yes	No	Yes
	12	TS2	Finished post graduate degree	Yes	PGCE	12	10	Yes	Yes	No	Yes
Rationale for omission: *Only Grade 10 lessons were observed by the fieldworker, no Grade 12 observations were done.*	13	TS1	Finished degree or diploma	Yes	PGCE	17	17	Yes	No	Yes	No
P1-SCH15-TS2-I P1-SCH15-TS2-OB	15	TS2	Finished degree or diploma	Yes	Further Diploma of Education	11	11	Yes	Yes	Yes	Yes
P1-SCH16-TS1-I P1-SCH16-TS1-OB	16	TS1	Finished degree or diploma	Yes	College of Education Diploma	10	10	Yes	Yes	Yes	Yes

Secondary Analysis - Participant Selection Criteria											
Qualitative Data Selection for Secondary Data Analysis	**School Codes**	**Science Teacher Codes**	**Qualification Data from Science Teacher Questionnaires**					**Additional Data Available**			
								Interviews		**Observations**	
			Highest Level of Formal Education	**Teaching Diploma/ Certificate**	**Type of Diploma/ Certificate**	**Teaching Experience altogether (Total years)**	**Physical Science Teaching Experience (Years)**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Rationale for omission: *Missing Science Teacher Questionnaire for TS3 so not possible to identify qualifications; TS1 and TS2 omitted due to difficulty in associating NCS results with teacher as three Grade 12 Physical Science teachers.*	17	TS1	Finished post graduate degree	Yes	Further Diploma of Education	15	15	Yes	No	No	No
	17	TS2	Finished post graduate degree	Yes	Other	12	12	Yes	Yes	Yes	Yes
	17	TS3	Not available					Yes	Yes	No	Yes
P1-SCH18-TS1-I P1-SCH18-TS1-OB	18	TS1	Finished degree or diploma	Yes	Secondary Education Diploma	7	7	Yes	Yes	Yes	Yes

4.5 INSTRUMENTS

4.5.1 Teacher Questionnaires

The aim of the teacher questionnaires was to collect baseline information on teacher characteristics and classroom practices. The questionnaires for this study were adapted from previously existing questionnaires from the Progress in International Reading Literacy Study (PIRLS) 2006 and the Trends in Mathematics and Science Study (TIMSS). Many of the items in these questionnaires were similar to the information required for the primary study (CEA, 2010) and useful in addressing the secondary analysis research questions. The questionnaire consisted of five sections: Section 1 (teacher biographic items); Section 2 (classroom characteristics and practices, subject content readiness); Section 3 (classroom assessment); Section 4 (teacher interactions); Section 5 (attitude towards NCS) (CEA, 2010, p.10). The questionnaires were self-administered in order to facilitate the gathering of a large amount of information on a wide range of topics in a relatively short period of time (CEA, 2010, p.8).

4.5.2 Teacher Interviews

The first phase of teacher interviews were conducted to establish information on teacher attitudes, motivation for teaching Science, perceptions about learners, feelings about the NCS, and a personal account of lesson observation. The second phase of teacher interviews were subject specific and involved teacher ranking of topics by level of presumed difficulty, ranking of the learning strategies they use in their lessons and the frequency (CEA, 2010, p.12). All of the interviews were audio recorded by the fieldworkers.

4.5.3 Lesson Observations

The observation schedule for Phase II of data collection was a structured schedule to record information on the classroom environment, classroom practices, and a general summary of the fieldworker's impression of the lesson. The lesson observation field notes were transcribed and analysed using qualitative codes in Atlas-ti in order to identify themes in classroom practices.

4.5.4 National Senior Certificate Examination Results for Physical Science for 2009

The National Senior Certificate Examination Overall Pass Rates for Physical Science for 2009 were used as a measure of learner achievement. These results obtained from the GDE for the Grade 12 Physical Science learners were sorted according to school, associated with the respective Physical Science teacher, and analysed using SPSS for correlations.

4.6 DATA COLLECTION

The data used for this study was collected for the "Evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools" project. It was collected in three separate phases over the 2009 academic school year. The first phase of data collection occurred early in the second term and many of the collection activities were repeated in more than one phase in an attempt to evaluate consistent progress over the year; however, different information was focused on in each phase (CEA, 2010, p.7). Due to the nature of the research questions, and the availability of data, only the Phase II of the primary study was used.

Table 4.6 - Data Collection Instruments used by the CEA for the "Evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools" (CEA Technical Report, 2010, p.7)

Phase	Description/Activity
Phase I: Planning and Pilot	• Planning and pilot of the instruments
Phase II: Data Collection and Analysis	• Classroom observations; • Individual interviews with Science heads of department (HoD); • Individual interviews with FET Science teachers.

4.7 DATA ANALYSIS

The data were analysed using a combination of qualitative and quantitative analysis methods, which included the use of qualitative content analysis, quantitative descriptive statistics and correlation analysis. The data were analysed separately (QUAL + quan) and then brought back together afterwards. Qualitative content analysis is incorporated in the mixed method analysis because it can involve the use of both qualitative and quantitative data which can be analysed both qualitatively and quantitatively. There is also the possibility that the qualitative data could be transformed into quantitative data by counting the number of codes or themes that arise (Creswell & Plano Clark, 2007, p.12). Thus, a mixed methods analysis provides both quantitative and qualitative results which are combined to best address the aims and research questions.

4.7.1 Quantitative Data Analysis

Exploratory data analysis was used to look at the distribution of the data. Quantitative descriptive statistics were used to describe the data quantitatively to describe the data in terms of frequency distribution, mean, median, mode, range, standard deviation. For this, SPSS Software was used. Frequency tables were produced to allow further linkage between the quantitative data and the qualitative nature of teacher characteristics and classroom practices. Afterwards, correlations were generated between two variables, namely, the overall Physical Science pass rate per school with teacher characteristics and classroom practices. This was done by using bivariate correlation coefficients, specifically, Pearson and Spearman correlation coefficients. The Pearson correlation coefficient requires that in order for it to be an accurate measure of the linear relationship between two variables, the data must be interval. As such it should be organised in such a way as to offer a continuous range of responses whereby equal differences in the property being measured are represented by equal intervals on the scale (Field, 2009). Certain assumptions are required in order to establish whether the Pearson correlation coefficient is significant and valid. For example, the sampling distribution has to be normally distributed or from a large sample. Additionally, both variables should be normally distributed, or one of the variables can be a categorical variable provided there are only two categories (Field, 2009). It is important to recall that the closer the correlation coefficient is to +1 or -1, respectively indicates a strong positive or negative relationship. The results in SPSS will also indicate the sample size (N) and the significance value of the correlation. If the data is not normally distributed, then Spearman's correlation coefficient will be used. This test ranks the data and then applies the Pearson's equation to look at the interconnections between the

variables (Field, 2009). By using a variety of data analysis methods, and a combination of quantitative and qualitative methods, the researcher had the freedom to analysis the data in various ways to answer the research questions.

4.7.2 Qualitative Data Analysis

Qualitative content analysis involves working with transcribed, textual formatted, qualitative data by using qualitative codes and families (Henning, et al., 2004; Lee & Fielding, 2004). This process involved the generation of codes that relate to the research questions. The codes were created in such a way that they apply to more than one data type or segment. They were revised throughout the analysis process to fit across all of the data sources and segments (Lee & Fielding, 2004). Each concept in the conceptual framework was considered as a coding category and the set of coding categories was applied to a set of texts or coding schemes. The scheme is then systematically applied to all of the selected texts for the purpose of extracting uniform and standardised information (Franzosi, 2004). A computer program, specifically Atlas.ti, was used to analyse data electronically and provided a variety of options for creating codes, grouping them into themes, and further data analysis.

Content analysis allowed for the categorised data to be translated into quantitative scales which were transferred into multidimensional classifications. The content analysis process was made systematic and transparent by following rules and procedures; however, it is recognised that validity and reliability are areas of criticism for this approach (Lee & Fielding, 2004). To counter the argument that this type of data analysis may lead to superficial findings, mixed methods were used in order to follow the content analysis with more concrete, quantitative, analysis methods (Henning, et al., 2004). This was done by using qualitative content analysis in conjunction with descriptive teacher categories of teacher qualifications and quantitative analysis, in terms of correlations and descriptive statistics. The content analysis was very useful in that it large amounts of qualitative data were able to be analysed and used to generate themes within the data (Franzosi, 2004). Thematic content analysis was used to provide a clear picture of the basic content of the qualitative texts, namely, the transcribed Science teacher interviews and lesson observations (Franzosi, 2004). The codes listed in the table below directly relate to the literature review, conceptual framework and the research questions for the secondary data analysis research study. The codes were grouped according to the themes that emerged in terms of classroom practices. The research question, specifically, ‘What are the various classroom practices that are used by teachers with different categories of teacher characteristics?’ was

answered using a thematic content analysis on the teacher interviews and lesson observations. The related codes are presented in Appendix D and Appendix E. These were then interconnected with the categories of teacher qualifications from the teacher interviews and teacher questionnaires. Finally, quantitative analysis of the NCS Physical Science pass rates were interconnected with each qualitative theme and category of teacher qualification using correlations and descriptive statistics.

4.8 METHODOLOGICAL NORMS

Mixed methods research incorporates the use of abduction, inter-subjectivity and transferability. Abduction describes the connection between theory and the collected data in mixed methods research. This connection is a combination of both induction, which is typically a qualitative approach, and deduction, which is typically a quantitative approach. By using a pragmatic (mixed methods) approach, the process of moving from theory and data operates in both directions and moves back and forth between induction and deduction, utilising both qualitative and quantitative methods. This is sometimes accomplished by converting observations into theories and then assessing those theories (Plano Clark & Creswell, 2007). Discussing the concept of inter-subjectivity is necessary in mixed method research as it refers to the relationship of the researcher and the research process, and involves a combination of subjectivity (typically a qualitative approach) and objectivity (typically a quantitative approach). When using a mixed methods approach, the researcher has the freedom to shift between various frames of reference and levels of transferability (Plano Clark & Creswell, 2007). The term transferability is a combination of context (qualitative approach) and generality (quantitative approach) and refers to the pragmatic, mixed methods approach with regards to the degree of interpretation that can be made from the analysis. By using the mixed methods approach and incorporating the concepts of abduction, inter-subjectivity and transferability, freedom in data collection and analysis is provided and ultimately leads to the ability to address the research questions. Lastly, since mixed method research uses a combination of quantitative and qualitative research methods, it is important that the components of each of these are considered.

4.8.1 Quantitative Research

Considerations of both reliability and validity are necessary in quantitative research. Reliability can be defined as "the degree to which a test consistently measures whatever it is measuring" (Cohen, Manion & Morrison, 2007, p.141). For this reason, draft questionnaires were distributed to Science subject specialists for review prior to the pilot study (CEA, 2010). All questionnaires were then piloted at a random sample of three schools within the Pretoria area in order to determine the time frames that would be required for completion and in order to identify and address any issues with regards to the format of the questioning. This piloted data was captured and analysed to provide a template for the analysis process that would occur for the data (CEA, 2010, p.9). Validity is concerned with the correctness of the interpretations that can be taken from the research instruments (Cohen, Manion & Morrison, 2007) and whether the questionnaires can be interpreted to appropriately measure teacher's qualifications and classroom practices. The construct validity of the questionnaire used for this research study has been established in the sense that many of the components have been modified from the PIRLS and TIMSS instruments and effort has been made in assuring that these instruments measure what they are intended to measure. In addition to the quantitative measures, the components of qualitative methods must also be considered when conducting mixed methods research.

4.8.2 Qualitative Research

Qualitative research should consider trustworthiness. This can be supported by using methods such as, triangulation, disconfirming evidence, member checking, the audit trail, the use of thick, rich descriptions, prolonged engagement (length of study), and peer debriefing (Plano Clark & Creswell, 2007). Triangulation is the process of joining evidence from different individuals, types of data, and methods of data collection, into descriptions and themes. The information collected in the teacher interviews was triangulated with teacher responses to corresponding questions in the questionnaires and to the teachers' classroom practices. Disconfirming evidence was attempted by looking for teachers that are exceptions to the rest of the findings, that is, teachers with no professional qualifications who have good classroom practices and high learner achievement. Member checking was attempted and data was collected from more than one participant to check the accuracy of their account, for example, learner interviews asked similar questions on classroom practices and assessment to the teacher interviews. The Audit Trail refers to the collection and incorporation of primary sources, such as fieldwork notes, and copies of data that were included in the study. The use of thick, rich

descriptions increases the degree of external validity in the sense that the results can be generalised to a wider population or other cases. These qualitative narratives are present in the case studies in Chapter 6. Observations were made over two phases of data collection and involved both video and written observations. Interviews with teachers were audio recorded and the data was analysed in order to provide detailed descriptions of the teacher's classroom practices. Long-term observation in terms of prolonged engagement increases the scope of the study and prolonged observation increases the depth. The primary research study was conducted in four phases with three observation phase spread out over three school terms, each with weeklong observations. Peer debriefing occurred and the data analysis and results were reviewed by my supervisor and external evaluators. By using methods such as triangulation, disconfirming evidence, member checking, the audit trail, the use of thick, rich descriptions, prolonged engagement and peer debriefing, the trustworthiness of qualitative data collection and analysis was strengthened.

4.9 ETHICAL CONSIDERATIONS

Ethical approval was obtained for the "Evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools" project and all ethical considerations specified in that study will be maintained. These considerations include: informed consent which was completed by the GDE; measures were put forth to ensure confidentiality and anonymity; pre-publication access was discussed with the GDE. With regards to the aspects of confidentiality and anonymity all schools and teachers were assigned codes. For example schools were identified as School 1 (SCH1) through to School 18 (SCH18) and the Science teachers were randomly assigned a code of TS1, TS2 or TS3. Limitations do exist for this study and have been addressed in the following section.

4.10 LIMITATIONS

In the methodology of this study, the teacher certification is self-reported in the Science teacher questionnaires, ideally, this data should be supported by using the South Africa Council for Educators (SACE) certification; South African Qualifications Authority (SAQA) certification; and university transcripts. However, these documents were not collected or requested which is a limitation of this study and a recommendation for future research. However, the reliability of the analysis was strengthened by linking the interviews and questionnaires and further reinforced by the quality of teaching during observations and the amount of preparedness in

lesson planning. These characteristics are likely to translate into the quality of learning that takes place under the supervision of these teachers and measured by the 2009 Matric pass rates for FET Science in the 18 schools investigated in the GDE FET Study.

4.11 CONCLUSION

This chapter served to provide a description of the research methodology. The research methodology chapter began with a discussion of the research design in Section 4.2 where the paradigm of pragmatism was discussed in relation to the chosen mixed methods research design. The mixed methods research design was further conferred in Section 4.3 and entitled as research methodology. This was followed by a summary of the sample methods which were found in Section 4.4 and summarised the procedures that were used for the 18 different schools in the evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools project (CEA, 2010); and the sample methods for the secondary analysis. Section 4.5 described the instruments that were used in the primary study and in the secondary analysis, these instruments can be found in Appendix A, B, and C and on the accompanying CD. The data collection and research procedures were presented in Section 4.6, followed by details regarding the data analysis in Section 4.7. Finally, a discussion of methodological norms was offered in Section 4.8 and the ethical considerations in Section 4.9. Section 4.10 discussed some of the limitations of the secondary analysis and makes recommendations for future research in this area. Further recommendations will be put forth in Chapter 6. Whilst reading this chapter, one will notice that the research design and methods have been selected with consideration of the literature review in order to answer the research questions in line with the conceptual framework of the secondary analysis.

CHAPTER 5
ANALYSIS AND RESULTS

5.1 INTRODUCTION

This chapter begins with a reiteration of the objectives of the study, the research questions, and the key terms that were introduced in Chapter 1 (see Section 5.2). All of the data used for the secondary analysis in terms of the Science teacher interviews, Science teacher observations, Science teacher questionnaires, notes and reflections are available from the researcher and the CEA at the University of Pretoria. The instruments used for the secondary analysis are provided in Appendix A, B and C; and the codes for the Science teacher interviews and for the Science teacher observations are found in Appendix D and E, respectively. The complete set of quantitative data analysis tables can be found in Appendix F and the NCS final examination pass rates for the sample schools 2009 Physical Science have been organised according to school and teacher and presented in Appendix G. As discussed in Section 4.9, the teachers were assigned codes to ensure anonymity and used throughout the analysis and in reporting the findings of the secondary analysis. For example, SCH2-TS1 refers to School 2, Science teacher 1. Additionally, O is used in the personal communication citations to indicate that it refers to an observation field note, where I refers to an interview quotation. Section 5.3 serves to confer the analysis of the learner achievement results in terms of pass rates for the case studies. A discussion of the quantitative data analysis and results are presented in Section 5.4 by way of descriptive statistics (Section 5.4.1), frequency tables (Section 5.4.2), and Pearson correlation coefficients (Section 5.4.3). Tables are included to illustrate the key components of each of the quantitative data outputs and discussed separately. Following the quantitative data analysis results, the qualitative data from the Science teacher questionnaires and interviews are tabulated in Section 5.5 (Table 5.15) and discussed for each of the seven selected Science teacher participants to provide information on their teacher characteristics, such as professional qualifications and years of related experience. Four case studies are portrayed in Section 5.6 in which the qualitative data from the Science teacher questionnaires, interviews and observations has been combined for each of the selected teachers in an attempt to provide thick, rich descriptions of each teacher's profile. Following this, a discussion of the themes that emerged from the observation and interview analysis are presented in Section 5.7. Lastly, the themes from both the Science lesson observations and Science teacher interviews are brought together and discussed in relation to the existing literature in this Section 5.8.

5.2 OBJECTIVES, RESEARCH QUESTIONS AND KEY TERMS

This section serves as a reiteration of the objectives of the study, the research questions and the key terms that were introduced in Chapter 1. The research questions fall in line with the conceptual framework that was presented and discussed in relation to existing literature in Section 3.3 in Chapter 3, and the research methodology of the secondary analysis as discussed in Section 4.3 in Chapter 4.

5.2.1 Objectives of the Study

The aims of this study can be realised through data collection by way of the Gauteng Department of Education's "Evaluation of the implementation of the Further Education and Training (FET) National Curriculum Statement in Gauteng Secondary/Combined Schools" (CEA, 2010).

1. To develop a framework for classifying teacher characteristics within the context of the study by using aspects of LaTurner's (2002) teacher qualifications categories and Rogan and Grayson's (2003) 'profile of the capacity to support innovation';
2. To report on the classroom practices for each category of teacher characteristics in the FET study sample population using the above mentioned classification framework for teacher characteristics; and
3. To report on the extent to which the pass rates of the Grade 12 classes for the National Senior Certificate Examination results are related to each category of teacher characteristics and classroom practices.

5.2.2 Research Questions

Flowing from the objectives of the study, the main research question was: *What is the interconnection between Grade 12 Physical Science teacher characteristics, classroom practices, and National Senior Certificate Examination results in Gauteng secondary schools?*
From the main research question, the following sub-questions were identified:

- What are the different categories of teacher characteristics in the FET study sample population?
- What are the various classroom practices that are used by teachers in each of the categories of teacher characteristics?

- To what extent are the pass rates of the Grade 12 classes for the National Senior Certificate Examination results related to each category of teacher characteristics and classroom practices?

5.2.3 Key Terms

For the purposes of this research study, the subsequent terms were defined as follows:

Table 5.1 – Definitions for the key terms for the secondary analysis study.

Teacher Characteristics	Classroom Practices	Learner Achievement
• Teacher qualifications (Bolyard & Moyer-Packenham 2008; LaTurner, 2002; Darling-Hammond, 2000); • Related experience (James & Benson, 2008; Onwu, 2000); • Subject content knowledge (SCK) and pedagogical content knowledge (PCK) (Alder, et al., 2009; Beets, 2009; van Dijk & Kattmann, 2007).	• All of the activities and learning strategies that teachers use in their lessons (Abrahams & Millar, 2008; Stols, Kriek & Ogbonnaya, 2008; Fricke, et al., 2008; Hattingh, Aldous & Rogan, 2007; Onwu & Stoffels, 2005; Gwimbi & Monk, 2003; Rogan & Grayson, 2003).	• The performance of Grade 12 Physical Science learners on the 2009 National Senior Certificate Examinations.

5.3 ANALYSIS OF THE LEARNER ACHIEVEMENT RESULTS

The qualitative profiles for the seven case study teachers were tabulated with the quantitative data for learner achievement, in terms of pass rates, in Table 5.2.

Table 5.2 – Physical Science Pass Rates according to increasing Categories of Teacher Qualifications and Teaching Experience (Years).

Teacher Code	Categories of Teacher Qualifications for South Africa FET Physical Science	Physical Science Teaching Experience (Years)	Pass Rate (>30%) for NCS Physical Science Examinations (%)
SCH2-TS1	Non-qualified	18	14
SCH18-TS1	Teaching Diploma	7	5

Teacher Code	Categories of Teacher Qualifications for South Africa FET Physical Science	Physical Science Teaching Experience (Years)	Pass Rate (>30%) for NCS Physical Science Examinations (%)
SCH5-TS2	Teaching Diploma	8	13
SCH16-TS1	Teaching Diploma	10	14
SCH15-TS2	Teaching Diploma	11	39
SCH9-TS1	Postgraduate Degree or Certificate in Education	7	25
SCH4-TS2	Postgraduate Degree or Certificate in Education	40	72

The Science teacher characteristics for the selected case study participants have been presented in Table 5.2 and arranged according to increasing Categories of Teacher Qualifications for South Africa FET Physical Science and Physical Science Teaching Experience (Years). The Pass Rate (>30%) for NCS Physical Science Examinations (%) has been included in the last column for each teacher. According to the data in Table 5.2, increasing experience within a category of teacher qualification is associated with increasing learner achievement, in terms of pass rate. In table 5.2 it is illustrated that the learners who were taught by SCH4-TS2 had the highest pass rate and that SCH4-TS2 also had the most experience and the highest level of qualifications of all of the teachers in the secondary analysis. A pattern is evident which illustrates that teachers within a category of qualification, teachers with increasing related experience are associated with higher learner pass rates. For example, the teachers who have been allocated to the category ‘teaching diploma’ have been organised according to teaching experience which corresponds with increasing learner pass rates. This pattern is true for each of the categories of qualification in the case study teachers. The findings for the case study interconnections between categories of qualification, related experience and learner pass rates are further supported by the Pearson correlation coefficients and will be presented in Section 5.4.3. The pass rates that are associated with each teacher for the 2009 NCS Grade 12 Examination results for Physical Science for the schools from the primary data set have been included in Appendix G for further reference.

5.4 DISCUSSION OF THE QUANTITATIVE ANALYSIS

The instrument that was selected for the quantitative component of the mixed methods analysis was the Science Teacher Questionnaire (see Appendix A), in conjunction with the 2009 pass rates for Physical Science (see Appendix G). Each of the items in the questionnaire were given a numerical value, or ranked according to an ordinal scale, depending on the nature of the item. The quantitative findings from the mixed methods secondary analysis (QUAL + quan) are first reported in this section using descriptive statistics (Section 5.4.1), frequencies (Section 5.4.2) and Pearson correlation coefficients (Section 5.4.3) with the outputs from SPSS being included in Appendix F. From the primary sample population, nineteen Grade 12 Physical Science teachers were further analysed for the quantitative component of the secondary data analysis using descriptive statistics (Table 5.3), frequencies (Tables 5.4-5.13) and Pearson correlation coefficients (Table 5.14). Each frequency table is followed by a description of the contents in terms of the questionnaire items and relevance to the study. The item responses and frequency data were organised according to the conceptual framework in terms of teacher characteristics and classroom practices and interconnected with the qualitative data in Chapter 6.

5.4.1 Descriptive Statistics

Descriptive statistics were generated using SPSS and complete output sets are included in Appendix F. Table 5.3 illustrates the descriptive statistics for the items from the Science Teacher Questionnaire that are relevant to the research questions in relation to teacher characteristics, classroom practices, and learner achievement.

Table 5.3 – Descriptive statistics for the items included from the Science Teacher Questionnaire for the secondary data analysis.

Descriptive Statistics						
	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Overall pass rate	19	5,00	72,00	26,6316	4,44276	19,36552
Highest level of formal education	19	5,00	8,00	5,6316	0,19058	0,83070
Teaching diploma/certificate	19	0,00	1,00	0,9474	0,05263	0,22942
Categories of teaching qualifications	16	1,00	5,00	4,1250	0,23936	0,95743
Type of diploma/certificate	15	3,00	9,00	5,8667	0,62386	2,41622

Descriptive Statistics						
	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Teaching experience altogether	19	7,00	40,00	15,1579	1,79874	7,84052
Physical Science teaching experience	19	5,00	40,00	15,0000	1,85277	8,07603
Readiness to teach 'Motion in 2 dimensions'	18	1,00	3,00	2,3889	0,14323	0,60768
Readiness to teach 'Work power and energy'	18	2,00	3,00	2,6667	0,11433	0,48507
Readiness to teach 'Doppler effect'	18	2,00	3,00	2,6111	0,11824	0,50163
Readiness to teach 'Colour'	18	1,00	3,00	2,6667	0,14003	0,59409
Readiness to teach 'Diffraction and interference'	18	2,00	3,00	2,6667	0,11433	0,48507
Readiness to teach 'Wave nature of matter'	18	1,00	3,00	2,3889	0,14323	0,60768
Readiness to teach 'Electrodynamics'	18	1,00	3,00	2,5000	0,14575	0,61835
Readiness to teach 'Circuits'	18	1,00	3,00	2,0556	0,17097	0,72536
Readiness to teach 'Electromagnetic radiation'	17	1,00	3,00	2,2941	0,16638	0,68599
Readiness to teach 'Optical properties of matter'	18	1,00	3,00	2,1667	0,12127	0,51450
Readiness to teach 'Organic molecules'	18	1,00	3,00	2,7222	0,13541	0,57451
Readiness to teach 'Mechanical properties of matter'	18	1,00	3,00	2,3889	0,16447	0,69780
Readiness to teach 'Organic macromolecules'	18	1,00	3,00	2,5556	0,14512	0,61570
Readiness to teach 'Rate and extent of reactions'	18	2,00	3,00	2,7222	0,10863	0,46089
Readiness to teach 'Electrochemical reactions'	18	2,00	3,00	2,7778	0,10083	0,42779
Readiness to teach 'Chemical industry'	18	1,00	3,00	2,2778	0,17723	0,75190
The extent to which teachers record various types of assessment	19	2,00	4,00	3,6842	0,13361	0,58239
The extent to which teachers feel that the requirements of assessment impacts negatively on time available for teaching and learning	19	1,00	4,00	3,3158	0,20308	0,88523
The extent to which teachers make use of feedback on assessments to support individual learners	19	2,00	4,00	3,6842	0,13361	0,58239

Descriptive Statistics						
	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
The extent to which teachers feel the results of the external examination is a true reflection of learners' attainment of learning outcomes	19	1,00	4,00	2,6316	0,19058	0,83070
The extent to which teachers feel that assessment provides useful evidence of learners' understanding and use it to plan subsequent lessons	19	3,00	4,00	3,7895	0,09609	0,41885
The extent to which teachers identify learners' strengths and advise them how to develop them further	19	3,00	4,00	3,7895	0,09609	0,41885
The extent to which teachers the next lesson is determined more by prescribed curriculum than by how well learners did in the last lesson	19	1,00	4,00	3,2632	0,21415	0,93346
The importance of the curriculum in informing teaching	18	3,00	5,00	4,3889	0,18327	0,77754
The importance of the textbook in informing teaching	18	3,00	5,00	4,1667	0,18524	0,78591
The importance of the learners' progress through assessment in informing teaching	19	2,00	5,00	4,1579	0,19138	0,83421
The importance of the informal classroom assessment in informing teaching	18	2,00	5,00	4,1667	0,20211	0,85749
The importance of the consulting with colleagues in informing teaching	19	2,00	5,00	4,2105	0,19615	0,85498
The importance of the cluster meetings in informing teaching	19	1,00	5,00	3,7368	0,32302	1,40800
The importance of the teacher workshops in informing teaching	19	1,00	5,00	3,8421	0,27850	1,21395
The importance of group work in implementing NCS	19	2,00	5,00	3,7895	0,24873	1,08418
The importance of cooperative learning in implementing NCS	18	2,00	5,00	3,9444	0,20567	0,87260
The importance of direct instruction in implementing NCS	18	2,00	5,00	4,0556	0,18912	0,80237

Descriptive Statistics						
	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
The importance of project work in implementing NCS	19	2,00	5,00	4,1053	0,21487	0,93659
The importance of individual work in implementing NCS	19	2,00	5,00	3,8947	0,28505	1,24252
The importance of drill and practice in implementing NCS	19	1,00	5,00	3,7895	0,30184	1,31567
The importance of problem solving in implementing NCS	18	2,00	5,00	4,6111	0,20031	0,84984
The importance of hands on activities in implementing NCS	18	2,00	5,00	4,5000	0,20211	0,85749
The importance of teacher demonstration in implementing NCS	18	2,00	5,00	4,1667	0,23221	0,98518

The overall pass rate for the final NCS examination results was analysed for the learners of nineteen Grade 12 Physical Science teachers and is a measure of the attained curriculum in terms of learner achievement. According to the Department of Basic Education (DBE), the pass rate for Physical Science is defined as the percentage of learners who have obtained greater than 30% for their NCS examination results. The minimum pass rate for the data set was 5% and the maximum pass rate was 72%, with a mean result of 26,63% (standard error of 4,44 and standard deviation of 19,37). The pass rates for all of the nineteen schools in the study have been included as Appendix G.

Several teacher characteristics were self-reported in the Science Teacher Questionnaires and have to do with aspects of professional qualifications and related experience. The minimum ‘highest level of formal education’ that was reported was given a value of 5 and represents that the teacher has finished a degree or diploma. The maximum ‘highest level of formal education’ that was reported was given a value of 8 and denotes that the teacher has successfully completed a postgraduate PhD degree. The mean result for highest level of formal education was 5,63 which signifies that most of the teachers in the sample have attained a first degree or diploma (standard error of 0,19 and standard deviation of 0,83). Most of the teachers in the sample conveyed that they possess a teaching diploma or certificate, and only one teacher out of the

19 reported that they do not possess a teaching qualification. The frequencies of the highest level of formal education are presented in Table 5.4.

The categories of teaching qualifications (see Table 4.2) range from 1 to 5 with:

- 1 indicating that the teacher is non-qualified,
- 2 that the teacher has an unsuitable teacher qualification (for example, a primary school teacher qualification),
- 3 that the teacher has a non-teaching specialist qualification only (such as a Bachelor of Science degree),
- 4 that the teacher has a teaching diploma from a college, and
- 5 that the teacher has a postgraduate certificate or degree in education.

The majority of the teachers in the study reported to have teaching diplomas which is further exemplified in the statistics and frequency tables for the 'type of diploma/certificate' (Table 5.4) and 'Categories of teaching qualifications' (Table 5.5). The frequencies of each type of certificate/diploma are illustrated in Table 5.6 and range from a Secondary Education Diploma to a PGCE. The range for total years of teaching experience is between 7 years and 40 years with a mean value of 15,16 years (standard error of 1,80 and standard deviation of 7,84). The Physical Science teaching experience varied from 5 years to 40 years for the teachers in the sample with a mean value of 15,00 years (standard error of 1,85 and standard deviation of 8,08).

The questionnaire asked teachers to respond in terms of their readiness to teach various Grade 12 Physical Science topics with either 'not ready' (value of 1), 'ready' (value of 2), or 'very ready' (value of 3). For the topic 'motion in 2 dimensions', a mean value of 2,39 (standard error of 0,14 and standard deviation of 0,61) is recorded which indicates that most of the teachers in the sample were ready or very ready to teach this topic. The teachers chose similar responses for all of the topics that were listed for the Grade 12 topics, signifying that most of the teachers felt ready or very ready to teach the topics specified in the NCS. This is a rudimentary measure of the self-perceived level of SCK for each of the Science teachers in the sample.

The self-perceived level of PCK for each of the teachers has been recorded in the extent to which they agree with the importance of aspects of assessment. The extent to which teachers

record various types of assessment to track learner performance ranged from ‘disagree a little’ (value of 2) to ‘agree a lot’ (value of 4) with a mean of 3,684 (standard error of 0,13 and standard deviation of 0,58) depicting that most teachers agree with the statement and believe that they use various types of assessment to track learner performance. The scope to which teachers feel that the requirements of assessments impact negatively on time available for teaching and learning fluctuated from ‘agree a lot’ (value of 4) to ‘disagree a lot’ (value of 1) with a mean of 3,315 (standard error of 0,20 and standard deviation of 0,89) signifying that most teachers agree with this statement and believe that the requirements of assessments impact negatively on time available for teaching and learning. The degree to which teachers make use of feedback on assessments to support individual learners ranged from ‘disagree a little’ (value of 2) to ‘agree a lot’ (value of 4) with a mean 3,684 (standard error of 0,13 and standard deviation of 0,58) indicates that most teachers agree with the statement and make use of feedback on assessments to support individual learners. The extent to which teachers feel the results of the external examination is a true reflection of learners' attainment of learning outcomes extended from ‘agree a lot’ (value of 4) to ‘disagree a lot’ (value of 1) with a mean of 2,63 (standard error of 0,19 and standard deviation of 0,83) representing that most teachers disagree slightly with this statement. The magnitude to which teachers feel that assessment provides useful evidence of learners' understanding and use it to plan subsequent lessons ranged from agree a little (value of 3) to agree a lot (value of 4) with a mean of 3,79 which reveals that most of the teachers feel that assessment provides useful evidence of learners' understanding and use it to plan subsequent lessons. The degree to which teachers use assessments to identify learners' strengths and advise them how to develop them further ranged from ‘agree a lot’ (value of 4) to ‘agree a little’ (value of 3) with a mean of 3,79 (standard error of 0,10 and standard deviation of 0,42) representing that most teachers agree with this statement and that a number of the teachers in the sample use assessments to identify learners' strengths and advise them how to develop them further. The extent to which teachers’ next lessons are determined more by prescribed curriculum than by how well learners did in the last lesson fluctuated from ‘agree a lot’ (value of 4) to ‘disagree a lot’ (value of 1) with a mean of 3,26 (standard error of 0,21 and standard deviation of 0,93) indicating that several teachers agree with this statement to some extent. All of these items from the questionnaire have been included as frequency tables (Tables 5.9-5.13) in order to provide a better indication of the frequency of each response.

In relation to PCK and planning, the teachers were asked to rank the importance of various items in informing their teaching on a scale of responses (1=low, 2=rather low, 3=neutral, 4=rather high, 5=high). The importance of the curriculum in informing teaching had a range of responses between 3 and 5 with a mean of 4,39 (standard error of 0,18 and standard deviation of 0,78) signifying that most of the teachers believe that the curriculum is of high importance in informing their teaching. The importance of the textbook in informing teaching also had an array of responses between 3 and 5 with a mean of 4,17 (standard error of 0,19 and standard deviation of 0,79) indicating that most of the teachers believe that the textbook is of high importance in informing their teaching. The importance of the learners' progress through assessment in informing teaching had a variety of responses between 2 and 5 with a mean of 4,16 (standard error of 0,19 and standard deviation of 0,83) demonstrating that most teachers in the sample feel that it is important to use the learners' progress in assessments to inform their teaching. The importance of the informal classroom assessment in informing teaching had a range of responses between 2 and 5 with a mean of 4,17 (standard error of 0,20 and standard deviation of 0,86) showing that most teachers give informal assessment a high priority in informing their teaching which falls in line with the National policy on assessment. The importance of the consulting with colleagues in informing teaching had an assortment of responses between 2 and 5 with a mean of 4,21 (standard error of 0,20 and standard deviation of 0,86) which is indicative that most of the teachers view consulting with colleagues as having a substantial influence in informing teaching. The importance of the cluster meetings and attending teacher workshops in informing teaching were given less importance and the results ranged from 1 to 5 with a mean of 3,74 and 3,84, respectively.

In terms of classroom practices, the teachers were asked to rank various classroom activities in relation to how important they are in implementing the intended curriculum, the NCS for Grade 12 Physical Science. The responses with regards to the importance of each item ranged from 1 to 5 on a scale of responses (1=low, 2=rather low, 3=neutral, 4=rather high, 5=high). The responses for group work ranged between 2 and 5 with a mean of 3,79 (standard error of 0,25 and standard deviation of 1,08). The responses for cooperative learning varied between 2 and 5 with a mean of 3,94 (standard error of 0,21 and standard deviation of 0,88). The responses for the importance of direct instruction in implementing the NCS ranged between 2 and 5 with a mean of 4,06 (standard error of 0,19 and standard deviation of 0,82), signifying that most of the teachers felt that direct instruction is an important methodology in the successful implementation of the NCS. The importance of project work was prioritised higher (mean 4,11)

than individual work (mean 3,89) and drill and practice (mean 3,79) in implementing the NCS. The importance of problem solving (mean 4,61) was rated as being a more important methodology than hands on activities (mean 4,50) or teacher demonstrations (mean 4,17) in implementing the NCS. The frequency tables for each of the descriptive statistics are presented in the following pages and will serve to provide more detailed insight into the quantitative significance of the questionnaire responses for the various teacher characteristics and classroom practices that have been emphasised previously.

5.4.2 Frequency Tables

The frequency tables for all of the items in the Science Teacher Questionnaire have been included in Appendix F. Only the frequency tables for the items that had potential correlations with learner achievement results, or appeared to be significant, have been included in this section. Each table is followed by a qualitative description of the contents in relation to the research questions and conceptual framework.

Table 5.4 – The Highest Level of Formal Education for each of the teachers in the sample population.

Highest Level of Formal Education	Frequency	Percent
Finished degree or diploma	10	52,6
Finished postgraduate degree	7	36,8
Finished postgraduate degree - Masters	1	5,3
Finished postgraduate degree - PhD	1	5,3
Total	**19**	**100,0**

Table 5.4 illustrates the highest level of formal education for each of the teachers in the sample population. Ten of the teachers reported that they have finished a degree or diploma, seven of the nineteen have finished some sort of postgraduate degree, one teacher has finished a postgraduate degree at the Masters level, and one teacher has finished a postgraduate degree and obtained a PhD.

Table 5.5 – Categories of Teaching Qualifications for each of the teachers in the sample population.

Categories of Teaching Qualifications	Frequency	Percent
Non-qualified	1	6,3
Teaching Diploma	10	62,5
Postgraduate Degree or Certificate in Education	5	31,3
Total	**16**	**100,0**

Table 5.5 serves to illustrate the categories of teaching qualifications for each of the teachers in the sample population. These categories have been exemplified previously in Table 4.2 in the modified classification scheme from that created by LaTurner (2002) in order to better represent the qualifications that are present in Gauteng Schools. It is important to note that none of the teachers in the sample reported to have only a non-teaching specialist qualification, such as a Bachelor of Science degree or equivalent. Additionally, none of the teachers reported to have an unsuitable teacher qualification that is not specifically for FET level. Only one of the teachers in the sample was non-qualified, ten had a teaching diploma and five had some form of postgraduate degree or certificate. The various frequencies of the types of qualifications are depicted in Table 5.6 below.

Table 5.6 – Type of Teaching Diploma/Certificate for each of the teachers in the sample population.

Type of Teaching Diploma/Certificate	Frequency	Percent
Secondary Education Diploma	4	26,7
3-year College of Education Diploma	2	13,3
4-year College of Education Diploma	1	6,7
ACE	1	6,7
Further Diploma of Education	2	13,3
HED	2	13,3
PGCE	3	20,0
Total	**15**	**100,0**

Table 5.6 displays the various type of teaching diplomas and certificates that each of the teachers in the sample population possess. Four of the participants left this section of the questionnaire blank and did not select any of the above responses. One of the four missing responses was for a teacher who had reported in a previous item that she did not possess any form of teaching qualification or certificate. Thus, one teacher was confirmed to be unqualified. Four of the fifteen teachers self-reported that they have a Secondary Education Diploma, two of the teachers have a 3-year College of Education Diploma, one teacher has a 4-year College of Education Diploma, one teacher has an Advanced Certificate of Education (ACE), two teachers have Further Diplomas of Education, two have postgraduate Higher Education Diplomas (HED), and three have Postgraduate Certificates of Education (PGCE). Related to teacher qualifications and thus to performance in the teaching and learning of Science at FET level, is the number of years of teaching experience. The following table (Table 5.7) gives some indication of the total teaching experience, in years, for each of the teachers in the sample population.

Table 5.7 – Total Teaching Experience (Years) for each of the teachers in the sample population.

Total Teaching Experience (Years)	Frequency	Percent
7.00	3	15,8
10.00	2	10,5
11.00	2	10,5
12.00	3	15,8
15.00	1	5,3
16.00	1	5,3
17.00	1	5,3
18.00	3	15,8
22.00	1	5,3
25.00	1	5,3
40.00	1	5,3
Total	**19**	**100,0**

Table 5.7 illustrates that the total teaching experience (in years) for each of the teachers in the sample population ranges from 7 years to 40 years with more than half of the teachers having less than 12 years of experience in teaching. Subject specific teaching experience is illustrated in Table 5.8 and ranges from 5 years to 40 years with half of the teachers having less than 12 years of experience in teaching Physical Science.

Table 5.8 – Physical Science Teaching Experience (Years) for each of the teachers in the sample population.

Physical Science Teaching Experience (Years)	Frequency	Percent
5.00	1	5,3
7.00	2	10,5
10.00	3	15,8
11.00	2	10,5
12.00	2	10,5
15.00	1	5,3
16.00	1	5,3
17.00	1	5,3
18.00	3	15,8
23.00	1	5,3
25.00	1	5,3
40.00	1	5,3
Total	**19**	**100,0**

The information depicted in Tables 5.9 to 5.11 indicates how ready teachers believed they were to teach three of the Grade 12 topics that had slight negative correlations with learner achievement as seen in Table 5.14. The topics were motion in 2 dimensions, electromagnetic radiation, and mechanical properties of matter.

Table 5.9 – Indication of preparedness for teaching the Grade 12 topic 'motion in 2 dimensions' for each of the teachers in the sample population.

Readiness to teach the topic 'motion in 2 dimensions'	**Frequency**	**Percent**
Not ready	1	5,6
Ready	9	50,0
Very ready	8	44,4
Total	**18**	**100,0**

As seen in Table 5.9, only one teacher indicated that they were not ready to teach the topic 'motion in 2 dimensions', with nine indicating that they were ready, and eight as very ready. One of the Grade 12 teachers did not respond to this item.

Table 5.10 – Indication of preparedness for teaching the Grade 12 topic 'electromagnetic radiation' for each of the teachers in the sample population.

Readiness to teach the topic 'electromagnetic radiation'	**Frequency**	**Percent**
Not ready	2	11,8
Ready	8	47,1
Very ready	7	41,2
Total	**17**	**100,0**

As visible in Table 5.10, two of the teachers specified that they were not ready to teach the topic 'motion in 2 dimensions', with eight indicating that they were ready, and seven as very ready. Two of the Grade 12 teachers did not respond to this item.

Table 5.11 – Indication of preparedness for teaching the Grade 12 topic ‘mechanical properties of matter’ for each of the teachers in the sample population.

Readiness to teach the topic ‘Mechanical properties of matter’	Frequency	Percent
Not ready	2	11,1
Ready	7	38,9
Very ready	9	50,0
Total	**18**	**100,0**

As depicted in Table 5.11, two of the teachers specified that they were not ready to teach the topic ‘mechanical properties of matter’, with seven indicating that they were ready, and nine as very ready. One of the Grade 12 teachers did not respond to this item.

Table 5.12 – The extent to which teachers in the sample population report that they ‘identify learners' strengths and advise them how to develop them further’.

Identify learners' strengths and advise them how to develop them further	Frequency	Percent
Agree a lot	15	78,9
Agree a little	4	21,1
Total	**19**	**100,0**

The extent to which teachers in the sample population report that they ‘identify learners' strengths and advise them how to develop them further’ has been included as Table 5.12. None of the teachers in the sample disagreed with this statement and 78,9% agreed a little with the remaining 21,1% agreeing a lot. These responses provide an indication of teacher competency in terms of PCK. Another response associated with teacher PCK is illustrated below in Table 5.13 and shows the extent to which teachers in the sample population report that they ‘make use of feedback on assessments to support individual learners’. Only one teacher disagreed a little with this statement, none disagreed a lot and 14 of the 19 teachers agreed a lot which indicates a high understanding of PCK. As discussed in the literature review, high levels of

PCK would require that teachers make use of both formal and informal assessments to provide feedback and support to their learners.

Table 5.13 – The extent to which teachers in the sample population report that they 'make use of feedback on assessments to support individual learners'.

Make use of feedback on assessment to support individual learners	Frequency	Percent
Agree a lot	14	73,7
Agree a little	4	21,1
Disagree a little	1	5,3
Total	**19**	**100,0**

5.4.3 Pearson Correlation Coefficients

The Pearson correlation coefficients were used as a quantitative analysis method for the Science teacher questionnaire responses. The analysis for the questionnaire items has been included in Appendix F and ten of the items from the questionnaire have been presented in Table 5.14. These items have been selected based on their significance, or importance in answering the research questions. As such, some of the items that have been included in this section have no significant relationship which is speculated to be a result of the small sample size; however, the items have been analysed and discussed in this section because they deal with important aspects of the research. Each of the selected items are facets of the definition for teacher characteristics to some extent and can be further divided into professional qualifications, related experience, SCK and PCK. Specifically, professional qualifications ('Highest Level of Formal Education', 'Categories of Teaching Qualifications', 'Type of Teaching Diploma/Certificate'), related experience ('Total Teaching Experience (Years)', 'Total Physical Science Teaching Experience (Years)'), SCK (Readiness to teach: 'Motion in 2 dimensions', 'Electromagnetic radiation', and 'Mechanical properties of matter'), and PCK (The extent to which teachers: 'Make use of feedback on assessments to support individual learners', and 'Identify learners' strengths and advise them how to develop them further').

Table 5.14 – Correlations using the Pearson Correlation Coefficient for the items in the Science Teacher Questionnaire according to the Grade 12 teacher responses from the sample population.

		Overall Pass Rate
Overall Pass Rate	Pearson Correlation	1
	Sig. (2-tailed)	
	N	19
Highest Level of Formal Education	Pearson Correlation	,057
	Sig. (2-tailed)	,818
	N	19
Categories of Teaching Qualifications	Pearson Correlation	,381
	Sig. (2-tailed)	,145
	N	16
Type of Teaching Diploma/Certificate	Pearson Correlation	,416
	Sig. (2-tailed)	,123
	N	15
Total Teaching Experience (Years)	Pearson Correlation	.495*
	Sig. (2-tailed)	,031
	N	19
Total Physical Science Teaching Experience (Years)	Pearson Correlation	.477*
	Sig. (2-tailed)	,039
	N	19
Motion in 2 dimensions	Pearson Correlation	-,396
	Sig. (2-tailed)	,104
	N	18
Electromagnetic radiation	Pearson Correlation	-,315
	Sig. (2-tailed)	,217
	N	17
Mechanical properties of matter	Pearson Correlation	-,366
	Sig. (2-tailed)	,135
	N	18
Make use of feedback on assessments to support individual learners	Pearson Correlation	-,346
	Sig. (2-tailed)	,147
	N	19
Identify learners' strengths and advise them how to develop them further	Pearson Correlation	-.599**
	Sig. (2-tailed)	,007
	N	19

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
b. Cannot be computed because at least one of the variables is constant.

According to the data analysis in Table 5.14, the highest level of formal education had an insignificant correlation with learner achievement in terms of pass rate, $r = 0,06$, $p > 0.05$, for the 19 participants. This relates to existing literature and falls in line with the findings from Darling-Hammond (2000) which reported that the level of qualification was a less significant indicator of learner achievement than subject specific teaching certification. According to the Categories of Teaching Qualifications (Table 4.2), devised for the purpose of the secondary analysis as a modified version of LaTurner's (2002), there is an indication of a slightly positive relationship; however, it is not possible to state the significance of the correlation in the larger population due to the limitations of the sample size (N=16). The Pearson correlation for categories of teaching qualifications was $r = 0,38$, $p > 0.05$. The type of teaching diploma/certificate was related to learner achievement in terms of pass rates; however, the small sample size (N=15) limited the extent to which Pearson's correlation could be used to determine the significance, $r = 0,42$, $p > 0.05$. The relationships between related experience and learner achievement have somewhat strong correlations, despite the limitations of the sample size (N=19), and indicate potential for further investigation and research. Pearson's correlation revealed a significant relationship between the total teaching experience in years and learner achievement, specifically, pass rates, $r = 0,50$, $p < 0.05$. The total Physical Science teaching experience in years also had a positive correlation with learner achievement, specifically, pass rates, $r = 0,48$, $p < 0.05$.

The items that showed an indication of potential negative correlations between teacher content knowledge (SCK and PCK) and learner achievement were based on self-reported readiness to teach the Grade 12 topics. Three examples of these possible relationships with pass rates are for teacher preparedness to teach motion in 2 dimensions, $r = -0,40$, $p > 0.05$., electromagnetic radiation, $r = -0,32$, $p > 0.05$, and mechanical properties of matter, $r = -0,37$, $p > 0.05$. The extent to which teachers in the sample population report that they 'identify learners' strengths and advise them how to develop them further' has been included as Table 5.12. It is interesting to report that none of the teachers in the sample disagreed with this statement and 78,9% agreed a little with the remaining 21,1% agreeing a lot. These responses provide an indication of teacher PCK; however, the Pearson correlation coefficient indicates that there is a possible negative relationship between teachers who report that they 'identify learners' strengths and advise them how to develop them further' and with pass rates, $r = -0,35$, $p > 0.05$. Another response that is associated with teacher PCK is illustrated in Table 5.13 and shows the extent to which teachers in the sample population report that they 'make use of feedback on

assessments to support individual learners'. This item has a significant negative correlation with pass rates, $r = -0{,}60$, $p < 0.01$. As discussed in the literature review, high levels of PCK would require that teachers make use of both formal and informal assessments to provide feedback and support to their learners. In order to further investigate the interconnection between teacher characteristics, classroom practices and learner achievement, seven teachers were selected as case studies.

5.5 DISCUSSION OF CASE STUDY SCIENCE TEACHER CHARACTERISTICS

Science Teacher Qualifications and Teaching Experience for the selected case study participants are presented in Table 5.15. The rationale for organising the data in this particular format stems from literature, particularly that which was discussed in the literature review (see Chapter 2) regarding research done by Darling-Hammond (2000) and LaTurner (2002).

Table 5.15 - The Science Teacher Qualifications and Teaching Experience for the selected case study participants.

Teacher Code	Highest Level of Formal Education	Teaching Diploma/ Certificate	Type of Diploma/ Certificate	Teaching Experience altogether (Total years)	Physical Science Teaching Experience (Years)
SCH2-TS1	Finished degree or diploma	No	N/A	18	18
SCH18-TS1	Finished degree or diploma	Yes	Secondary Education Diploma	7	7
SCH5-TS2	Finished degree or diploma	Yes	Other	17	8
SCH16-TS1	Finished degree or diploma	Yes	College of Education Diploma	10	10

Teacher Code	Highest Level of Formal Education	Teaching Diploma/ Certificate	Type of Diploma/ Certificate	Teaching Experience altogether (Total years)	Physical Science Teaching Experience (Years)
SCH15-TS2	Finished degree or diploma	Yes	Further Diploma of Education	11	11
SCH9-TS1	Finished post graduate degree	Yes	HED	7	7
SCH4-TS2	Finished degree or diploma	Yes	HED	40	40

The teaching qualifications that were given as options on the Science Teacher Questionnaire were: Secondary Education Diploma; College of Education Diploma; Advanced Certificate of Education (ACE); Further Diploma of Education; Postgraduate University or Technikon Univ/Tech Higher Education Diplomas (HED); Postgraduate Certificate of Education (PGCE). The teachers selected for the secondary analysis all possess unique qualifications. According to the Science Teacher Questionnaire data, SCH2-TS1 has self-reported to have finished a degree or diploma, but that he does not have a teaching diploma or certificate. Three of the teachers reported that they have finished a degree or diploma and some type of diploma in education; specifically, SCH15-TS2 has a Further Diploma of Education; SCH16-TS1 has a College of Education Diploma; and SCH18-TS1 has a Secondary Education Diploma. SCH5-TS2 has finished degree or diploma and has a teaching diploma or certificate that was not included in the list on the questionnaire and thus recorded as other. SCH4-TS2 and SCH9-TS1 both have reported that they possess Postgraduate University or Technikon Univ/Tech Higher Education Diploma (HED). Thus, there are five types of professional qualifications: Non-teaching qualified; College of Education Diploma; Secondary Education Diploma; Further Diploma of Education; and Higher Education Diploma (HED).

As revealed in Section 2.2.3 of the literature review, there is a positive relationship between teachers' experience (in terms of total years of teaching) and Science achievement (Bolyard &

Moyer-Packenham, 2008). Darling-Hammond (2000) found that the benefits of experience appear to level off after about five years, with new teachers being less effective than senior teachers. The quantitative secondary data analysis indicated possible relationships between related experience and pass rates which were discussed in the Section 5.3.3. The case study teachers were chosen because they possess unique contrasts with regards to their teacher qualifications, classroom practices, and/or learner achievement. The case study narratives are offered in the succeeding section.

5.6 CASE STUDIES

The questionnaire data, qualitative interview and observation summaries, and learner achievement results have been organised in this section according to teacher and school in the form of narrative case studies. This has been done with the intention to provide thick, rich descriptions of each teacher's profile with regards to the concepts illustrated in the conceptual framework in Chapter 4 and in order to illustrate the interconnection between teacher qualifications, classroom practices and learner achievement. The teachers selected for the case studies are those who possess unique contrasts with regards to their teacher qualifications, classroom practices, and/or learner achievement. Case Study A is of a Science teacher who has completed a postgraduate degree, possesses a HED, and has seven years of teaching experience, all of which are in Physical Science. Case Study B is of a Science teacher who has a College of Education Diploma and ten years teaching experience in Physical Science. The Science teacher for Case Study C has completed a Further Diploma of Education and has eleven years of teaching experience in Physical Science. In contrast, a Science teacher who does not have a teaching degree or diploma, but who has completed another type of degree or diploma, has been selected for Case Study D. The teacher has eighteen years of teaching experience, all of which are in Physical Science. Other pathways of qualifications exist in South Africa; however, none of the other qualification types were present in the complete data sets for the secondary data analysis. This has been included in the recommendations and limitations sections later in Chapter 6.

5.6.1 Case Study A: *heal the nation*

This case study exemplifies the teacher characteristics and classroom practices for a Science teacher who has completed a postgraduate degree, possesses a HED, and has seven years of teaching experience, all of which are in Physical Science. The teacher that was selected for this particular case study was the Grade 12 Physical Science teacher from School 9.

Science Teacher Interview:

The Science teacher from School 9 entered the teaching profession because he wanted to "heal the nation or maybe assist the nation" (Personal Communication: SCH9-TS1-I). The Science teacher seemed to have a desire to help the learners reach their potential, regardless of the contextual factors. His main educational goal for his learners was to "…stimulate the learners in Science, make them love Science. Because with Science, they can achieve what they want to become in the future" (Personal Communication: SCH9-TS1-I).

He believed that he would be able to help his learners reach their goals in STEM careers, that he wanted to help to *save the nation, you know, we can get what the nation is requiring, which is more engineers and more specialized people such as IT* (Personal Communication: SCH9-TS1-I). He had confidence in his abilities as a teacher and felt that he was able to prepare his learners for tertiary education in areas of STEM studies and said that *if they do go to higher learning then they will be able to know exactly what they will be doing there* (Personal Communication: SCH9-TS1-I). He came across as very confident with regards to his SCK and was able to comment on the NCS and problems with the delivery of the NCS in South Africa being well aware of what is required in the teaching of Physical Science at the three most important years to prepare the learners to enter higher education and address the need for scarce skill training.

> *The curriculum is well set for people who really can achieve. If they go to university with this curriculum, if they are taught very well, from Grade 10 to Grade 12, then it is addressing what is required in the outside world. The problem is the delivery, how we teachers deliver the NCS is a problem that I noticed when coming to high school. Our teachers are not willing to learn. If you are not willing to learn, you will never cope with our NCS, you will never cope, that's for sure* (Personal Communication: SCH9-TS1-I).

Having worked at the University of Pretoria as a lecturer, he was well aware of the expectations of tertiary studies and how the under preparedness of the learner typically entering universities, which would affect their performance even in first year of study.

> *Teaching Science with these learners is something that I do not find any problem with, because I have been teaching at Tukkies, first year foundation chemistry, so I always wanted to come back to high school and just come and compare the standard of what is happening in high school and tertiary level* (Personal Communication: SCH9-TS1-I).

This experience both at university and school level was evident in his classroom practices, where he showed evidence of advance planning and was resourceful enough to organise

practical activities, despite the shortage of resources and the contextual factors that were present in his school. His resourcefulness was evident in that he accessed resources from the University of Pretoria laboratories and support from the Science lecturers. He seems to be quite resourceful in obtaining external assistance and commented that his *HoD is not knowledgeable enough with Science,* as the HoD is a Maths specialist. In addition, he does not receive support from the provincial government or even from the district (see Theme 3 in Section 5.7-8 for the excerpt from the discussion between the interviewer and the Science teacher at School 9).

He comments on the fact that he has a fully stocked laboratory but equipped with expired chemicals that have never been used. This is a well-documented issue in literature and recorded that providing resources, without the education and training on how to properly use them and integrate practical demonstrations and tasks in lessons, is fruitless. This teacher commented that he wished the school had a well-equipped laboratory whose sole function was that of a science laboratory and not a multi-purpose room.

Even without the resources, this Science teacher's competency in terms of PCK was illustrated in the way he planned his lessons, combing it very effectively with his chemistry knowledge and SCK. In preparing and planning his lessons, he researched the curriculum content and chose methods of delivery that allowed him to best implement it with the needs of his learners being a priority.

He was also quite explicit in terms of how his planning followed a logical sequence with regards to the intended curriculum. This also illustrates his level of competency with regards to PCK. He explained that his planning was informed by the leading outcomes and he explained that he *designed each and every lesson looking at what I want to achieve in the whole topic. So each lesson is aimed to address … what we want to achieve.* The teacher prepares his learners with a verbal outline of each topic so that they have clear understanding of the module so they know what to expect.

The teacher makes use of lecture-style presentation method, which he justifies because he only has a chalkboard and a whiteboard. Despite being in a limited environment, he did attempt to utilise the resources that were available. He showed an understanding of the needs of the learners and the importance of informal assessment strategies, such as learner questioning, to guide his lessons. He incorporates problem-solving strategies in order to reinforce the theoretical content that he presents.

Overall, this teacher seemed to have a clear idea of what is required for teaching FET Science and was knowledgeable about the expectations for tertiary Sciences courses, specifically, first year chemistry at the University of Pretoria. He went into teaching in order to minimise the gap between high school Science and university and thought that he would be able to assist the country in influencing learners to enter STEM careers. He was resourceful in obtaining equipment for practical lessons and demonstrations and made a plan to educate his learners regardless of the resources that were available to him at School 9. He showed competency with respect to both PCK and SCK and seemed to have several noteworthy teacher characteristics and classroom practices.

Science Lesson Observation:

The Physical Science teacher from School 9 was observed while he presented a lesson to 38 Grade 12 learners. All of the learners that were recorded on his class list were in attendance, with no absentees. During the lesson observation, the following infrastructure was recorded: the light in the classroom was adequate; the writing board/visual aids were visible to all learners; there was enough space between desks and tables for the teachers and learners to move around; there were enough chairs/work spaces for all learners; however, the room was not adequately ventilated; nor was the temperature of the room conducive to learning.

The lesson started 20 minutes late, which left only 25 minutes of the 45 minute period. According to the observation notes, the learners were late for the lesson because it takes them 20 minutes to change classes during exam time. As a result, there was less learning than would usually be expected and most of the lesson time was wasted as the teacher had to wait for the learners to arrive. It was also recoded that there is a lack of time management in the school as a whole (Personal Communication: SCH9-TS1-O).

The Grade 12 Chemistry lesson specifically dealt with chemical equilibrium. The level of lesson content was appropriate to the expected Grade 12 level. According to Rogan and Grayson's (2003) Profile of Implementation, the following classroom interactions with regards to learner involvement took place at Level 1: *the learners responded to and initiated questions and the teacher used a textbook effectively*. In terms of Gwimbi and Monk's (2003) SLOS Learner-teacher interactions, the explanation of lesson content and instructions were delivered by the teacher; there was recorded evidence of learner-led questioning which was followed by the learners writing answers to exercises. The lesson was delivered as a whole group activity

where the teacher asked the learners to open their textbooks in order to answer some of the questions together as a class and despite the late start and shortened lesson time, the learners managed to solve more than three questions while working together.

> *The educator starts by writing the topic on the chalkboard and tells the learners what they are going to learn about. He explains what Chemical Equilibrium is. He teaches by giving examples. The learners were cooperative. They asked their teacher questions where possible. He gave them a thorough explanation of everything that they asked* (Personal Communication: SCH9-TS1-O).

He gave the learners thorough explanations and seemed confident with the work which is indicative of competency in terms of SCK and PCK. The teacher and learners answered some of the textbook questions together. The learners worked as a group and then independently at the end of the lesson. The teacher seemed to have a good rapport with the learners and they were engaged throughout the lesson.

Overall, the teacher had several interview responses that indicated competency in both SCK and PCK; however, missing out on 20 minutes of a lesson could be detrimental to learning and covering the curriculum, if this is regular practice.

5.6.2 Case Study B: *for the love of children*

This case study will exemplify the teacher characteristics and classroom practices for a Science teacher who has a College of Education Diploma and ten years of teaching experience, all of which are in Physical Science. The teacher selected for this particular case study was the Grade 12 Physical Science teacher from School 16.

Science Teacher Interview:

The Science teacher from School 16 entered the teaching profession because she believed that teaching was a calling; she also did so for the love of children and a desire to help the nation. She chose Science because she loved it at school and she had a desire for more knowledge. In her interview, she stated that she had failed Grade 12 Physical Science when she was in school. The teacher mentions that she was only an ‘average’ learner in school and hence failed. This is concerning as average learners should not be failing. However, she later attended a technical school to upgrade her results. She then went on to obtain a College of Education Diploma and afterwards she began teaching Physical Science.

> *So I wasn’t that clever learner, but I loved doing Physical Science. I was average in the class. Therefore I failed Grade 12. Then I was disappointed. Then I decided to get to this, by then it was, before it was constituted [inaudible 1:56] when it was technical, I*

> *went to the technical school to upgrade my symbols in maths and Physical Science because I loved them very much. Therefore I decided to be a Science teacher because at that Technical I gained more knowledge so I have realised the Physical Science and maths, they are the most important subjects. So I must go for teaching so that I can be able to help our nation with those two subjects* (Personal communication: SCH16-TS1-I).

The teacher mentioned that most of her learners struggle academically and that they generally lack intrinsic motivation.

> *The learners in the class they are not that intelligent. There are those learners who are intelligent. But some, especially the boys, what I see from them they are lazy to learn. It's the laziness because when you teach them you see that they understand what you are saying. But the minute you give them something you want them to do, it is then that you realise that these people, they don't understand whatever I was saying so some of them they are obstinate to have the very stubborn children in our classes* (Personal Communication: SCH16-TS1-I).

She reported during the interview that there are behaviour and attendance issues in her Science lessons. She explained that she uses specific techniques for coping with difficult learners such as isolating them all in one group and then teaches the rest of the class while she stands next to the difficult group to watch them closely and keep them on task.

> *…the problematic learners, we are not supposed to chase them away so I take them and put them in the same group. Then I tell them I will attend to you while they are still doing those things of them. I just give the other group the instructions so that they can work. So these problematic learners, I always am standing there next to them so that they work* (Personal communication: SCH16-TS1-I).

The teacher mentioned that she struggles with classroom management and has difficulty getting her learners to work in her lessons. She said that she often notices that the learners do work for other subjects during Physical Science and that they are disruptive in her classroom. Poor classroom management is an indication of a shortfall of in terms of classroom practices and in PCK.

> *They resist whatever you are doing; they don't want to learn, so each and every time you must force them to do your work, so we are left behind because of such things, people who are not cooperative with what we are doing. They always do their own thing. Like, for instance when sometimes we are busy teaching Physical Science and the next period is English, they were given the homework in English They forgot to write it* (Personal Communication: SCH16-TS1-I).

During the interview, the teacher admitted that she often teaches in a language other than English which is the medium of examination and the intended medium of instruction. She justified this because English is not her language and that she struggles to describe what she

expects them to do. She then commented that when she is upset or disturbed by their behaviour, she will speak in English so that they know that she is upset.

> *I do speak their language, because English is not my language I cannot emphasise in English what I want them to do. So, if I am a bit disturbed by them, so I talk in my English so that they understand what they are doing and I don't like it* (Personal communication: SCH16-TS1-I).

The teacher reported that she had taught her Grade 12 learners last year for Grade 11, that she has had them for two years now. During the interview, she stated that when she went to revise Grade 11 work to the Grade 12s on electricity, which they did not remember the work and that she had to reteach it. *So, I started with the electrostatic, knowing that I did this with the learners previously, but it doesn't look like that. You have seen, it is not like that. It was a new thing to them, but as you go on they still remember, oh it's this thing, then when you go further they forgot again* (Personal Communication: SCH16-TS1-I). The Science teacher mentioned that she will try to encourage her learners to work in future lessons by perhaps creating worksheets that are formatted in a puzzle way because the learners enjoy doing puzzles.

She acknowledges that she has shortfalls in her content knowledge*, …especially with the new things in Physical Science that I haven't learnt at school. That I haven't learnt at teacher's level* (Personal Communication: SCH16-TS1-I). But, she states that she is happy to attend workshops or courses to increase her competency, *…I am always willing to learn, I am always reading, I do ask people who understand better than I do, so that I gain more knowledge to give it to the learners* (Personal Communication: SCH16-TS1-I). She mentions difficult topics and the need for support in order to develop her SCK so that she is able to better teach C2005. Another indication of a possible shortfall in content knowledge is that she relies heavily on textbooks for the content that she is required to teach. She comments that the textbooks that she has are not in line with the new content and that they do not contain the information that she needs. She uses incorrect terminology in her interview with regards to the prescribed topics which further indicates that she struggles with the English language and with the Science key terms that are essential for Grade 12 content delivery.

> *I think we as teachers need more support especially in those subjects, I mean the content, where we are teaching them for the first time like Doppler effects, like the diodes and so on. Since those that are new in the syllabus, I think we sometimes have to as teachers attend somewhere maybe where we will be able to be given those, so that we understand more, so that we gain more knowledge on what we know. Because the textbooks that we are using, they do not have that much information* (Personal Communication: SCH16-TS1-I).

It is exemplified in the Science teacher's interview responses that she has several shortfalls in her PCK and these are translated into inappropriate and ineffective classroom practices. In addition to these shortfalls, several indicators of potential shortfalls in SCK were also presented. A summary of the Science lesson observation for the Physical Science teacher at School 16 will paint a more vivid picture to illustrate these shortfalls.

Science Lesson Observation:

The Physical Science teacher from School 16 was observed while she presented a lesson to a Grade 12 class with 41 learners in attendance and 45 on the class register list. With regards to infrastructure, the following was recorded during the lesson observation: the room was adequately ventilated; the temperature of the room was conducive to learning; the light in the classroom was adequate; the writing board/visual aids were visible to all learners; there were enough chairs/work spaces for all learners and there was enough space between desks and tables for the teachers and learners to move around.

The lesson consisted of revision of Grade 11 physics on electrostatics. According to Gwimbi and Monk's (2003) Science Lesson Observation Schedule (SLOS) the learner-teacher interactions were primarily teacher-led questioning. The lesson was introduced with the Science teacher posing questions about key definitions to probe the learners' prior knowledge, *What is electrostatic? Two opposite charges will? Two same charges will? What is coulombs law? In words and equation?* (SCH16-TS1-O). The teacher posed questions to the class as a whole and the SLOS lesson teaching strategy was a whole group activity where the teacher provided the questions and the learners solved the problems together using their calculators. The learners were then nominated to give data to fill in after the teacher wrote the formula on the board. It was not recorded whether she made the link between the revision of the Grade 11 work and the Grade 12 work during the lesson. The teacher showed some evidence of planning in that she had prepared photocopies from a Grade 11 textbook. The learners did some of the working out on the board. Thus, the lesson consisted of copying and writing answers to exercises as learner activities according to the SLOS items. The teacher did not do any of the working out but rather instructed which questions the learners should do. This strategy could be indicative of a shortfall in the teacher's SCK; or lack of preparation, and thus, a shortfall in PCK. The teacher assigned homework at the end of the period for extra practice, with no formal conclusion to the lesson.

5.6.3 Case Study C: *to rise above poverty*

This case study will exemplify the teacher characteristics and classroom practices for a Science teacher who has a Further Diploma of Education and eleven years of teaching experience, all of which are in Physical Science. The teacher that was selected for this particular case study was the Grade 12 Physical Science teacher from School 15.

Science Teacher Interview*:*

The Science teacher from School 15 entered into the field of teaching because of employment opportunities. She began her career as an unqualified teacher and later obtained her teaching qualifications.

> *Okay, initially I wanted to go into research, industrial research, but due to problems of employment, I ended up teaching. But, for the first few years I was just doing teaching, but not professionally, but I ended up enjoying imparting that knowledge to them, you know. Therefore, I got my qualifications to major in … to do qualifications in teaching* (Personal Communication: SCH15-TS2-I).

The Science teacher's main achievement goal is for her learners to be able to use Science beyond matric, in their future studies and careers. *I don't want it to end in the classroom, but I want to meet them one day, saying I'm doing research … due to the foundation that you gave me at school.* She wants them to be able to link the real world and the scientific world and explains that education is the only way for her learners to rise above poverty. The teacher reports that the school is adequately furnished with equipment and resources, and she is resourceful in utilising those that are available to her.

The Science teacher uses a variety of sources when planning lessons and takes advantage of the free copies of textbooks that were given out by publishers to promote the purchase of their books for the implementation of the NCS. *I have five different textbooks for the same grade, and then I always refer to it, when I have a topic that I should teach, I check and find that in two textbooks it is not there, it is not even available, but you go to the next three and you find it and you look at the best way to teach it.* In addition to researching the content that should be covered in each lesson, she invests a lot time in extra Physical Science lessons after school. She said that extra lessons are necessary in order to cover the content specified in the curriculum and remedy shortfalls in content that should have been learned in the previous grades. She also comments that the laboratory venue is *too small … to accommodate the 45 to 50 learners* and that extra lessons are essential every day *if you want your work to be done well.* Nevertheless, she has some misconceptions about how resources should be made available to

her and seems quite helpless about her situation and the context in which she teaches. She stated that she uses DoE frameworks to guide her planning and has interview responses that indicate some competency in PCK, however, significant shortfalls are evident in her misconceptions about the content and rationale for selecting appropriate classroom practices.

The teacher at School 15 comments that she prefers to teach in the computer lab using a CD with activities and a quiz-like format for the learners. She comments that the computer program allows the learners to assess their understanding as it gives them feedback as to whether they have selected the correct response or not. She encourages the learners to use the computer program and she explains the parts where the learners made mistakes when they return to class.

Science Lesson Observation:

The Physical Science teacher from School 15 was observed while she presented a lesson to a Grade 12 class with an expected number of 41 learners. There were 37 learners in attendance. The following infrastructure was recorded during the lesson observation: walls and floors of the classroom were clean; there was no signs of vandalism; the room was adequately ventilated; the temperature of the room was conducive to learning; the light in the classroom was adequate; however, the writing board/visual aids were not visible to all of the learners; there was not enough space between desks and tables for the teachers and learners to move around; and there were not enough chairs/work spaces for all of the learners. "The learners sit at the lab benches on stools and chairs, rather squashed in. Some have no place to sit and stand at the benches" (Personal Communication: SCH15-TS2-O).

The lesson topic was entitled optical phenomena and was supposed to be on lasers. The teacher introduced the lesson by using a poster with pictures of sunlight and dispersion through a prism. This sparked a brief discussion within the group. The teacher then put a pencil in a beaker of water and explained that refraction of light was occurring, which is revision of Grade 10 work. She explained that when light goes through glass (called the medium) the speed changes, the light bends and the wavelength can increase or decrease; it depends (but she does not say on what) (Personal Communication: SCH15-TS2-O). She then referred to the poster with refraction of light through a prism, which was also revision of Grade 10 work. She introduced the Grade 12 term 'laser' and then switched to an explanation about conductors and electrons during which she seemed to have some misconceptions about electron movement and problems identifying what they should be learning.

The lesson topic for lasers was new in the NCS and it was clear in the lesson observation that the teacher lacked confidence in this particular topic. She relied heavily on the textbook throughout the lesson. The lesson lacked coherence and the teacher was unsure of how the content linked with prior learning and the rest of the module. The lesson was mostly teacher-centred, where the SLOS learner-teacher interactions were predominantly teacher-led questioning and the SLOS lesson teaching strategy was as a whole group activity. The observation data states that the teacher asked questions very regularly and that the learners either responded not at all, or in chorus (Personal Communication: SCH15-TS2-O). The lesson was recorded as one that lacked cohesiveness, and did not seem to be well planned. The teacher switched between electromagnetic radiation and electricity and a discussion about the behaviour of electrons which illustrated some teacher misconceptions and a shortfall in SCK, specifically, the Science teacher stated that *electrons are completely stationary in a conductor before the switch is closed* (Personal Communication: SCH15-TS2-O). The lesson was not formally concluded and the bell rang before the Grade 12 work was addressed. The teacher said that she would continue with lasers in the subsequent lesson.

This lesson observation, in conjunction with the Science teacher interview, indicated several shortfalls in terms of classroom practices, PCK and SCK for the Science teacher at School 15. Specifically, in areas of relevance to the Grade 12 curriculum content and lesson delivery, the incomplete explanations and lack of cohesiveness indicate poor planning or none at all.

5.6.4 Case Study D: *a competent foundation for SCK*

This case study exemplifies teacher characteristics and classroom practices for a Science teacher who does not have a teaching degree or diploma, but who completed a degree or diploma. The teacher has eighteen years of teaching experience, all of which are in Physical Science. The teacher that was selected for this particular case study was the Grade 12 Physical Science teacher from School 2.

Science Teacher Interview:

The Science teacher from School 2 entered into the field of teaching because the government provided a grant for him to study – his family did not have the money for him to follow another course of study.

> *My parents did not have money, to send me through university. It was money outside the ability to from their resources to do that, as a result I was given a government grant,*

> *so I went through university from the then government of Rhodesia. The issue then was [that] … for the number of years that I would have spent at university, I would have to work for the equivalence as a teacher. So, I ended up having to teach for three years. And that is how I got into teaching* (Personal Communication: SCH2-TS1-I).

The Science teacher explained that his rational for choosing Science as a teachable subject was because he got an A in his O level result for Physical Science, two As in Maths, and one A in Biology. These results should have provided the teacher with a competent foundation for the SCK that was needed for his university studies.

> *…my Cambridge O level results showed that of the eight subjects that I wrote that I did best for Physical Science. I did Grade A Physical Science, I had one in Biology, I also had two in Maths. And I had mediocre results in languages, and in Geography and History. So, for my O level I went for the Sciences* (Personal Communication: SCH2-TS1-I).

The main achievement goal for the Grade 12 teacher is to see how many of his learners pass and go to University with his help. He describes the personal satisfaction of seeing learners pass that translates into an inner feeling that is not related to, or affected by, his earnings. The Grade 12 Science teacher tries to address the needs of the learners in his class who struggle by providing extra lessons. He states that, due to the differences of learners understanding, it is difficult for him to know where to aim his lessons. He is of the opinion that learners come to Grade 12 from previous grades without an adequate understanding of key concepts, which contributes to the difficulties that he experiences.

> *I am disappointed in the learners that have come from other educators. They seem not to appreciate the key concepts. The word is key concepts that unify the different Modules that make up the syllabus, are at times they gloss over what is terribly important, and give emphasis on what is not terribly important. Maybe it's the reflection of their abilities, in terms of knowledge, this background knowledge of Chemistry or Physics as a result when I receive them in Grade 11, I come up with a dog's breakfast. A mixture very varied, from those who are high background. In other words conceptual background, others are from very weak conceptual background* (Personal Communication: SCH2-TS1-I).

The school is supportive in that it provides space for extra lessons, which even need to be held during the school holidays due to the amount of difficulties experienced by his learners.

> *But when it comes to support right now I have asked for the hall, that the hall be allocated to me from Tuesday to Saturday for the whole of May and June. The principal was very, very supportive and at the end of today they will put up benches and chairs, etcetera. Clean it, etcetera. That will be dedicated for me to teach Physical Science after school. So the support is there* (Personal Communication: SCH2-TS1-I).

Despite the support that has been offered with regards to providing the hall for extra lessons, the Science teacher comments that there are problems with shortages in laboratory essentials, equipment and basic stationery supplies.

> *I need lights, I have got light only for ceiling there, I don't have lights here for using either the overhead which I have, but I can't use it 'cause there is no power in the cabling. I don't have hot water, I don't have a running tap in here, and I cannot do any simple experiment or demonstration… So, it is very difficult, actually for the Grade 12 to write an exam I had to fork out money from my own pocket to buy Typex paper in order to print their examination paper that is how bad things are. So, the support is very bad, equipment is very hard to come by, lab equipment. I would want to improvise maybe next year as I go through this over the holidays I'll start constructing my own ray boxes, my own electrical circuits, etcetera. But, there is nothing in this school* (Personal Communication: SCH2-TS1-I).

The Science teacher commented on his classroom practices and how he sets a competitive environment to encourage his learners.

> *I have created a competitive attitude in my class, every time we have homework or an assignment that is done, when it is done very well, I go out of my way to applaud the learners that have done well, normally I bring them up to the front of the class after distribution of the books. Then I make everybody stand up and applaud, that way there is a competition as to, in the next assignment am I going to the one that goes in front of the class. This gives some since of competition amongst the learners* (Personal Communication: SCH2-TS1-I).

He mentioned that there are issues with the attendance of the Grade 12 learners, which makes it difficult for them to attain the required knowledge in Science.

> *They are erratic in their attendance, it creates a lot of problems for me, especially when it comes to key concepts that they have missed, and as you appreciate that knowledge acquisition is incremental. You will have to get one step at a time, and if they miss one step and at times I am unaware of the fact that there absence was a longish one. Usually they could probably have an extended week-end which is not acceptable, I am not able to arrange for extra lessons for such learners, it is expensive for me to have an afternoon only to do a one on one with a learner just because they decided that day they had a bubalas (hangover) and not to come to school* (Personal Communication: SCH2-TS1-I).

Overall, the Science teacher at School 2 seems to have several teacher characteristics that indicate potential competency in SCK and PCK; however, some shortfalls in both are also indicated in the interview and are prevalent in the Science lesson observation data.

Science Lesson Observation:

The Physical Science teacher from School 2 was observed while he presented a lesson to a Grade 12 class with an expected number of 33 learners; however, only 23 learners were in

attendance. The following infrastructure was recorded during the observation: the room was adequately ventilated; the temperature of the room was conducive to learning; the light in the classroom is adequate; the writing board/visual aids were visible to all of the learners; there was enough space between desks and tables for the teachers and learners to move around; and there were enough chairs/work spaces for all of the learners; however, there were signs of vandalism in the classroom and the walls and floors of the classroom were not clean.

The lesson that was observed was on waves, specifically, two types of waves as transverse and longitudinal waves. This is Grade 10 content and as such not at the appropriate cognitive level for the Grade 12 learners, nor was it relevant to their curriculum. The teacher did not mention why he was revising this particular section nor did he attempt to link it with Grade 12 work. The learners were asked to label the crest, trough, wavelength and amplitude on a diagram of a transverse wave that was already drawn on the board. According to Gwimbi and Monk's (2003) SLOS, this lesson was a question and answer session where learners were requested to explain key terms related to waves. The fieldworker reported that the lesson ran smoothly and indicated that he believed the lesson was probably a repeated lesson. Learners showed little interest in the lesson they were talking to each other throughout the lesson. There was no conclusion to the lesson. The teacher seemed to have good confidence and understanding of the content that was presented; however, it was not regarded as Grade 12 work.

5.7 THEMES FROM THE QUALITATIVE DATA

The theme emerging from the observation and interview analysis are presented and discussed in this section. The themes from both the Science lesson observations and Science teacher interviews are brought together and discussed in relation to the existing literature. From these, further themes emerge from the qualitative data analysis which identifies some of the classroom practices that could be associated with the various teachers. These classroom practices are then discussed in relation to the literature review, as well as the literature for Gwimbi and Monk's (2003) Science Lesson Observation System (SLOS) and Rogan and Grayson's (2003) Profile of Implementation.

Several themes emerged from the Science lesson observations. The first theme to be discussed has to do with teacher characteristics that indicate either a shortfall or competency in their content knowledge. From the analysis of the Science teacher observations, certain behaviours, or teacher characteristics, indicated Science teacher competency while others indicated possible shortfalls. These teacher characteristics were influential on the classroom practices

that took place. In terms of classroom practices, teachers use their PCK to select the classroom practices that they feel best allow them to implement the content of the intended curriculum in the context in which they teach. Good classroom practices allow teachers to pass on their knowledge to their learners but require a balance of comprehensive SCK with sound pedagogical practices (PCK) (Alder, et al., 2009; Beets, 2009). Only a couple of the observed teachers seemed confident in their knowledge and allowed the learners to ask broad questions. They were not bound to a textbook and seemed resourceful to organise practical activities; however, the practical activities were not observed. Few teachers in the seven case studies utilised practical lessons or provided links between the content and how it applies to Science in society which are both essential components that should be seen in all classrooms implementing C2005 as it is intended. Most of the observed lessons were teacher-centred and involved a question and answer format where the learners responded in chorus or not at all. Several of the teachers taught content that was not at the Grade 12 level and did not link the purpose of revision to what is expected in Grade 12. No formal assessments were observed and most of the teachers attempted to informally assess the level of understanding by way of questioning. These teachers were selected for the case studies that are presented in Section 6.2.

Six common themes emerged from the qualitative data and are discussed in the following section in relation to existing literature. The six themes incorporate various components of teacher characteristics and classroom practices and are listed below:

1. SCK – indications of shortfalls and competency;
2. PCK – indications of shortfalls and competency;
3. Classroom practices – use of practical tasks and demonstrations;
4. Classroom practices – lesson planning, use of resources and preparation;
5. Classroom practices – relevance of the content to Grade 12;
6. Classroom practices – formal and informal assessment strategies.

5.8 THEMES IN RELATION TO EXISTING LITERATURE

In addition to the constructs that emerged as themes from the qualitative data, teacher professional qualifications and related experience are two important elements of teacher characteristics which have been discussed previously in Chapter 5, as they were primarily extracted from the Science teacher questionnaire data and confirmed by the interview transcripts, where possible. The data for these two constructs, teacher professional qualifications and related experience, has been tabulated in Table 5.2 to illustrate the

professional qualifications for the seven teachers that were selected as case studies for the secondary data analysis. The teachers were organised according to increasing categories of qualifications and related experience and reported on with regards to existing literature. Both of these teacher characteristics have been defined in the literature review and conceptual framework and are believed to influence a teacher's subject content knowledge (SCK) and pedagogical content knowledge (PCK) to varying degrees. The first two themes that emerged from the qualitative data are on competencies and shortfalls in content knowledge, specifically, SCK and PCK. These will be discussed under the respective sub-headings.

The next four themes have to do with the implementation of the intended curriculum with regards to classroom practices. Prominent literature in terms of context relevant classroom observations, particularly that reported by Rogan and Grayson (2003) and Gwimbi and Monk (2003), is used to discuss the themes in relation to their models of implementation and classroom observation schemes. Rogan and Grayson's (2003) Profile of Implementation is used in the discussion of the related themes in an attempt to illustrate the extent to which the intended curriculum was being implemented in the observed lessons as defined in C2005. The Profile of Implementation (Rogan & Grayson, 2003) was initially designed with the intent to investigate the scope of Science classroom interactions, practical work, integration of Science in society, and assessment practices. It is important to note that the 'lowest type of practice' is not defined by the Level 1 characteristics, but that Level 1 in each dimension rather illustrates some of the criteria that would be present in a good transmission type lesson. In this way, the Profile of Implementation is different from other developmental models, and as such, it is fairly probable that some of the schools included in the secondary analysis study may not display any of the practices that are described in any of the dimensions or levels of the Profile. This is the reason why components of the SLOS (Gwimbi & Monk, 2003) and the Profile of Implementation (Rogan & Grayson, 2003) have been used to further describe the components of the Science lesson observations for this study.

Theme 1 – Subject Content Knowledge – indications of shortfalls and competency

Throughout the analysis of the qualitative data, there are instances that indicate competency in SCK and those that indicate shortfalls in SCK. Examples of these indicators are illustrated in the following paragraphs. One indication of a shortfall in SCK is evident in the lesson observations where teachers give very broad explanations. It is speculated that these over-simplified, generalised explanations could be due to the teachers having only a limited

understanding of the material, or possibly due to the teacher oversimplifying the content because of the level at which they believe their learners are capable of learning. Either way, it could indicate a shortfall in content knowledge. This is exemplified in the lessons that were observed for the Grade 12 Science teacher at School 18. The Science teacher explained a demonstration on direct and indirect redox reactions and four excerpts from the observation field notes have been included below.

> *He then talks about direct and indirect redox reactions. He explains that he can immerse a copper plate in a zinc sulphate solution, and a zinc plate in a copper sulphate solution. One of the combinations would show a reaction, which could be established by weighing the metal plates. He does not mention the visible copper deposit that would form on the zinc plate. He does not write the possible chemical equations* (Personal Communication: SCH18-TS1-O).

> *He says it is 'advisable' to connect the red wire to the copper plate, but does not elaborate. He then explains about electrical neutrality and the migration of ions through the salt bridge, using examples of boys and girls 'migrating'. He says that 'bubbles' and a deposit would form. He then writes down the standard cell notation* (Personal Communication: SCH18-TS1-O).

> *A learner asks about the purpose of the experiment, the teacher says it is to demonstrate indirect redox reactions. The teacher's subject content knowledge seems to be insufficient, he does not mention the essence of the process, namely that this cell illustrates the basic principle on which batteries work. Also when learners ask questions, it seems that he does not understand what learners are really asking. His answers are merely repetitions of what he already said. He made a big issue of direct and indirect redox reactions, but he did not explain what was 'indirect' about the reaction discussed during this lesson* (Personal Communication: SCH18-TS1-O).

The observation of the lesson that was given by the Science teacher from School 15 also indicates that she has a shortfall in terms of the content knowledge required to teach Grade 12 content on lasers. According to the field notes, the teacher did not convey the material in a logical way and had a difficult time building up the concepts that should be prior knowledge to link with the new concepts on lasers.

> *The teacher puts a pencil in a beaker of water and asks the learners to observe closely. Some of them see the apparent bending of the pencil. The teacher remarks that it is the result of the refraction of light. She explains that when light goes through glass (called the medium) the speed changes, the light bends and the wavelength can increase or decrease; it depends (she does not say on what). The teacher refers back to the picture of light refracted through a prism and explains that light that refracts, takes a different direction so we see a different image. The teacher now introduces the word "LASER". She then starts talking about metals bonded in a metal structure, with free electrons in the structure. The teacher asks the class why copper is a good conductor. She goes into a lengthy discussion on why the electrons move (She asks questions now and then but doesn't wait for responses). She draws an electrical circuit on the board and*

> *explains that the cells provide energy to the electrons* (Personal Communication: SCH15-TS2-O).

The Grade 12 teacher at School 15 seemed textbook bound which could be an indication of a limited understanding and a shortfall in the SCK that is required to teach the Grade 12 lesson on lasers at the expected level according to the intended curriculum. This was a new topic in the NCS and it seemed as though the teacher lacked confidence in teaching this particular topic. In addition to this, she allowed the learners' questions and responses to take the lesson in another direction, which could be indicative of her lack of confidence, classroom management or other measures of PCK. Very little coherence was evident and the lesson observation indicated potential shortfalls in both SCK and PCK. The teacher SCH15-TS2 jumped between electromagnetic radiation and electricity. The teacher also made some errors during the lesson when she explained that 'electrons are completely stationary in a conductor before the switch is closed'. This is also indicative of a shortfall in SCK by way of misconceptions.

Some of the Science teachers said that some of the new topics in the C2005 were quite challenging and that despite having years of experience; they had to attend courses to develop their SCK in certain topic areas.

> *To be honest last year, I battled but like I said when I finished the course, I felt a little bit more empowered. Some of the new topics that I wasn't familiar with, I was a bit scared teaching them and it meant that you had to prepare. We were spoilt, if you teach a subject for long then you know the content, sometimes …[laughs] you are set in your ways and now suddenly they came in new topics and you had to familiarise yourself with that. Sometimes it's a bit scary …[laughs] if you are standing in front of the learners, are you really … have you prepared adequately for the lesson, but I feel much better this year teaching, especially the Grade 12's the learners* (Personal Communication: SCH5-TS2-I).

The teacher at School 5 demonstrated a higher level of SCK than most of the other teachers that were observed. This teacher realised that there were some weak areas in their content knowledge for the new topics and put forth effort into filling in the gaps. Some of the other indicators of competency in SCK were evident in the field notes. For example, during a lesson on electrolytic cells, SCH5-TS2 did not refer to any textbooks or notes whilst teaching the lesson. SCH5-TS2 was able to identify misconceptions and errors that were made by the learners, indicating confidence in her ability and SCK. During the lesson on chemical change, SCH5-TS2 reinforced the knowledge with application and problem-solving skills. Specifically, she told the learners what to look for and how to interpret what they see before starting to

answer a question. All of these characteristics are supported by literature as being indicators of high SCK.

There is a shortage of literature that has investigated the actual SCK of teachers, despite the fact that literature has suggested that SCK is indicative of teacher quality and learner achievement (Bolyard & Moyer-Packenham, 2008; Darling-Hammond, 2000). Over the past couple of decades, several researchers have tried to uncover teachers' SCK for specific topics (Potgieter, 2005). An example of a study that attempted to uncover the SCK of teachers was conducted by Jita and Ndlalane (2009) and reported that the teachers in their study had shortfalls in their SCK due to misconceptions and serious gaps in the conceptual understandings of the subject area. Various types of training and intervention programmes have been tried in South Africa increase teacher SCK and competency. It has often been recorded that teachers in South Africa have been given resources during INSET which are unused because the teachers continue to have shortfalls in SCK and PCK to successfully implement Science at FET level (Abrahams & Millar, 2008). Furthermore, if teachers are confident in their ability to respond to higher order cognitive level questions then they will also be more likely foster complex thinking within their classrooms (Abrahams & Millar, 2008). In order to fully understand teachers' professional knowledge it is imperative that adequate instruments are used as professional knowledge can be very difficult to conceptualise especially with regard to the interplay between subject content knowledge and pedagogical practices (Alder, et al., 2009; Jita & Ndlalane, 2009; Loughran, et al., 2004).

Theme 2 – Pedagogical Content Knowledge – indications of shortfalls and competency

Several factors emerged as indicators of competency and shortfalls in PCK during the qualitative data analysis. Examples of these indicators are illustrated in the following paragraphs. PCK involves the teacher understanding the intended curriculum and implementing it by way of various classroom practices that they believe will best allow their learners to acquire the content as specified. The curriculum requires that certain practical tasks are done independently as an assessment of the learners' ability to apply their knowledge in terms of practical investigations. The teacher at School 16 seems to have a misinterpretation of the intended curriculum and does not see this as being a necessary assessment task. She allows her learners to do the practical activities in groups and then write the report as if it were independent work. This makes the assessment task invalid and does not indicate what the

learners are actually capable of individually with regards to practical work. This is supported by her statement below.

> *We can do practicals, but in groups, we cannot do individually, because our material is not enough. We do in groups, but they write as individuals. So the problem when they are writing the laboratory report they have to say I have done such and such a thing, because they have done it in groups, so when they are writing individually they must say "I"* (Personal Communication: SCH16-TS1-I).

In reality, the teacher should have organised the learners into smaller groups that can rotate through the equipment in separate sessions to do the practical work individually. Several of the other teachers that were observed dealt with shortages of equipment in different ways. As an example, the teacher at School 9 regularly went to the University of Pretoria to borrow equipment in order to do practical lessons and demonstrations in his class. These are discussed further on in this section with regards to utilising practical lessons as a classroom practice.

The lesson observed at School 2 highlighted some shortfalls in teacher PCK. The lesson was a revision of Grade 10 work, despite the fact that it was being taught as a Grade 12 theory lesson on Physics. The lesson was structured as a question and answer session where the learners were requested to explain crest, trough, wavelength, amplitude. The lesson ran smoothly; however, the learners showed little interest in the lesson as they were talking to each other throughout the lesson which indicated that content was inappropriate in regards to what they should have been learning. The teacher did not formally conclude the lesson and the learners dispersed when the bell rang indicating poor time management and a lack of planning on the part of the teacher which are classroom practices that are indicative of poor pedagogy and a teacher with shortfalls in terms of PCK.

The observed lesson at School 5 was also not properly concluded and the learners were allowed to sit and talk about non-subject related things for a significant amount of time at the end of the period. The teacher felt that the majority of the responsibility for learning should be put on the learners and that Grade 12 learners should be at such a level that they do not need an educator to tell them what to do next.

> *I think the purpose of this curriculum was to prepare them for the outside world and to be ready for the situation outside but somehow I don't know if this is actually hampering our learners not to perform because they are not ready to take that responsibility on themselves to take control for their lives themselves. Because a learner at the level of a Grade 11 or 12 learner doesn't actually need an educator, I think that is my perspective. You should be at that level where even if the educator doesn't come to class, he will be*

> *able to study or work on his own but I don't see that. On days when I might not have been here, or for whatever reason it may be, you won't find a learner coming back the next day, ma'am you weren't here, I went and studied this section or I did this or that, that I don't experience. But I thought that the Grade 12 learners, we could leave them alone in the class and then you would come back, one of them would actually take the initiative and explain the work on the board for the rest of the class but I don't know, I don't see that* (Personal Communication: SCH5-TS2-I).

The teacher at School 16 identified gaps in the knowledge of her learners that should have been learned previously. This indicated potential competency in PCK as she reported that she needed to reteach the Grade 11 work in order for the learners to progress with the Grade 12 topics. However, at the same time, she reported that she had taught them in Grade 11, which indicates that she was possibly not thorough enough the previous year in covering the required topics, and perhaps this is an indication of a shortfall in PCK as well.

> *As it is the Grade 11 syllabus, I taught the learners that chapter in the previous [grade], I was expecting them to just, you know when we are revising, when we are asking questions, just talk like that [snapping of fingers], but I was surprised to find that they forgot whatever we have done. Then I have to start afresh with that chapter again. So, it is time wasting because it is there in the syllabus, but we have to revise it, not to start afresh. It must be part of revision* (Personal Communication: SCH16-TS1-I).

This same teacher reported that her learners seemed to enjoy doing puzzles and that she would like to create activities for her Grade 12 learners that would allow them to answer questions in a puzzle format. Experienced Science teachers would agree that this is not a very appropriate method for delivering Grade 12 Physical Science, so her inexperience in selecting appropriate teaching strategies could also be an indication of a shortfall in PCK. This particular teacher has been selected as one of the case studies in Chapter 6 and her teacher characteristics and classroom practices have been described in detail in Case Study B (see Section 6.2). Additional examples of indicators of shortfalls and competency for PCK and SCK have been offered in the case studies in Section 6.2, which have been presented in an attempt to provide thick, rich descriptions of four cases of teacher practice selected based on their distinctive teacher characteristics and classroom practices.

Another indicator of competency or shortfall in PCK is evident in the type of classroom practices that are selected to teach the intended curriculum. Teaching methods can range from being teacher-centred to learner-centred and should vary in each classroom depending on the type of activity that takes place. As mentioned in the literature review, teacher-centeredness refers to activities that are guided by the teacher, or where the teacher does most of the

explaining or demonstrations. This was evident in the observations for SCH9-TS1 who used a presentation method whilst teaching. It was an effective, teacher-centred method because the learners were able to follow what he was presenting. The teacher explained every concept in a step-by-step manner and every learner was engaged in what was taking place in the class (Personal Communication: SCH9-TS1-O). The majority of the lesson at School 5 was teacher-centred in the sense that the teacher did most of the talking. The lesson showed good coherence and planning; the new work was linked to old work in the introduction, the explanation of the working of lasers was very clear, and all the learners' questions were well answered or re-explained with different examples. After the main explanation, there was a shift to a more learner-centred approach where the learners initiated a question and answer session. The teacher maintained most of the control, so the lesson still had elements of a teacher-centred approach.

Learner-centred lessons would be those where the teacher asks as a facilitator and that put the responsibility of learning in the hands of the learners. An example of a learner-centred lesson would be one in which the teacher introduces a project or practical task and the learners work independently or together to perform the task without being led by the teacher. None of the observed lessons fell into this category of practice and were all teacher-centred. One type of learner-centred classroom practice is to use practical tasks, whereby, the teacher-centred version would be to conduct a demonstration. Both of these methods are necessary for the implementation of the intended curriculum at the FET level for Physical Science and are discussed in the next theme.

Jita and Ndlalane (2009) conferred that many researchers have found it difficult to study the concept of teachers' professional knowledge empirically, because it is tacit and contextual and not easy to verbalise. In addition, teacher unions are predominant in South Africa and would challenge the ethics of 'testing' teachers on their knowledge (Jita & Ndlalane, 2009). As such, additional research is needed in assessing teacher PCK using methods that are non-threating and ethically sound in order to inform development rather than to discriminate.

Theme 3 – Classroom practices – use of practical tasks and demonstrations

The use of practical tasks and demonstrations is specified in the NCS and essential in implementing the various components of the intended curriculum. Three Grade 12 Science teachers whose lessons were observed attempted to conduct classroom demonstrations to help develop concepts. However, none of the lessons for the selected teachers contained a complete practical task or demonstration that would fulfil the requirements of the intended curriculum,

as they were either incomplete or not grade appropriate. The Science teacher from School 18 explained that he could not physically conduct the practical as the school did not have water that day. He also mentioned that the school was frequently without water. In reality, this issue would have been easy enough for him to remedy as he could have brought a few litres of water to keep in the lab. Without actually conducting the demonstration, he attempted to describe what would happen during an experiment involving redox reactions; however, he did not mention the possible observations that would occur; what the end result would be or how it related in theory to the content being discussed. His explanation was not at the appropriate level for Grade 12 and illustrated that perhaps he either did not understand the depth of knowledge that the learners were required to know or that he did not understand the concepts himself. The following quotation from the lesson observation is offered as support for illustrating this particular shortfall.

> *The teacher took two small bottles containing chemicals and gave it to learners to look at and send along. He explains that he would have used these to make the electrochemical cell, if there had been water available. He then talks about direct and indirect redox reactions. He explains that he can immerse a copper plate in a zinc sulphate solution, and a zinc plate in a copper sulphate solution. One of the combinations would show a reaction, which could be established by weighing the metal plates. He does not mention the visible copper deposit that would form on the zinc plate. He does not write the possible chemical equations… The teacher's subject content knowledge seems to be insufficient, he does not mention the essence of the process; namely, that this cell illustrates the basic principle on which batteries work. Also, when learners ask questions, it seems that he does not understand what learners are really asking. His answers are merely repetitions of what he already said. He made a big issue of direct and indirect redox reactions, but he did not explain what was 'indirect' about the reaction discussed during this lesson* (Personal Communication: SCH18-TS1-O).

When the Science teacher at School 18 was asked about how he prepared for the lesson, his response indicated that he has some knowledge of what needed to be done in order to organise the practical lesson; however, he failed to execute this in the observed lessons.

> *I needed to prepare apparatus for different groups, I needed to prepare apparatus for myself because I must first demonstrate and the learners must perform on their own in their various groups* (Personal Communication: SCH18-TS1-I).

When demonstrations were actually physically conducted for the learners, as in the observed lesson for School 4, it was a revision of Grade 10 work. The teacher did an unprepared experiment in order to explain the concept of "sublimation" because it was a concept that the learners had not learned in previous grades, but the teacher felt that the learners should have had an understanding of the concept (Personal Communication: SCH4-TS1-O). The teacher at

School 15 also used a demonstration to develop a concept that should have been learned previously and was revision of Grade 10 work on refraction.

> *The teacher puts a pencil in a beaker of water and asks the learners to observe closely. Some of them see the apparent bending of the pencil. The teacher remarks that it is the result of the refraction of light. She explains that when light goes through glass (called the medium) the speed changes, the light bends and the wavelength can increase or decrease; it depends (she does not say on what)* (Personal Communication: SCH15-TS1-O).

The types of practical lessons that are specified in the curriculum, namely, C2005 would suggest that Level 3 and 4 practical work should be part of lessons. This level of work was not seen in any of the lesson observations and would be expected in the classrooms of exemplary teachers. According to Rogan and Grayson (2003), teachers operating at Level 3 of the profile of implementation would organise practical tasks that would encourage the learners to perform activities in small groups as a type of 'guided discovery' practical work. The learners would be expected to be able to write a scientific report and justify their conclusions in terms of the data collected if their teacher is operating at a Level 3 in this dimension (Rogan & Grayson, 2003). Level 4 of the profile of implementation requires that teachers organise practical tasks in such a way that the learners design and do their own 'open' investigations and the learners reflect on the quality of their own design and collected data, and make improvements. By being exposed to practical work at this level in the profile of implementation, learners should also be able to interpret data in support of competing theories or explanations (Rogan & Grayson, 2003).

When asked about conducting practical work, the teacher at School 4 indicated a shortfall in his understanding of the expectations of the curriculum and in his PCK. He clearly did not have knowledge that is specified within Rogan and Grayson's (2003) profile to meet any of the requirements in knowledge or practice.

> *It's prescribed for learners to do the practical in group work but in the case of practicals, it's monotonous doing the experiment on your own and it can get difficult if you have multiple readings to take because now you have to record volume, you have to record the thermometer reading – so, in group work sometimes it helps when you have to conduct the experiment because there are different roles within the investigation process and you do need other members to help you but just to participate to conduct the experiment otherwise if it was individual work I don't …[laughter] think it would have worked very nicely. They might have got the results but it would have been difficult* (Personal Communication: SCH4-TS1-I).

The teacher at School 5 reported on the availability of practical resources from the Department of Education during her interview. She explained that all the equipment required for conducting the prescribed practical activities has been provided in ready-to-use kit form so that teachers are equipped to conduct all of the prescribed Physics and Chemistry practical activities.

> *I love the smaller kits… you actually get quite accurate results and that is what I like about the smaller kits, scientific kits. And what I liked the equipment with the bigger groups, it's better to handle the small equipment where you have an overcrowded class than with the big equipment, that part I really liked. And they are not that easy to break I see, so they last very long [laughs]. And the chemicals are premixed - you don't have to dilute your acids or when you need to, everything is already in this micro kit and you can use from there and that I really like. The physics equipment, usually we struggled with physics equipment, but now everything, for every practical that they prescribe or what you want to do, the equipment is there, the basic equipment and I am not talking about the [inaudible word 00:25:59] stuff, just to make the lab look nice [laughs]. But, we can do all our practicals. Sometimes the quantity is not enough, like you have seen yesterday, but otherwise it doesn't hamper us from conducting the practical investigations* (Personal Communication: SCH5-TS2-I).

As recorded in literature, it seems that teachers who are interested in doing practical work will usually find ways to do so, even in the most poorly resourced schools (Fricke, et al., 2008; Hattingh, Aldous & Rogan, 2007; Rogan & Grayson, 2003). This was evident in the interview with the Science teacher at School 9 because he showed evidence of advance planning and was resourceful enough to organise practical activities, despite the shortage of resources and the contextual factors in his school environment. This is exemplified in the following excerpt from the discussion between the interviewer and the Science teacher at School 9.

> *TS:* *In terms of resources, I am relying heavily on the UP, the University of Pretoria, for example with Grade 10, they were supposed to do a separation method, chromatography to be precise, so I had to go to Tukkies [University of Pretoria] and borrow the TLC plates. They were so kind because they are supporting the NCS, so I had to rely on Tukkies. Apart from that, the school is not well resourced, they have got chemicals that have expired, so they are not well resourced, so I am relying heavily on Tukkies and lecturers that I know, on that other side of the Hatfield campus. I go there and they are always willing to assist me. This afternoon I am going there, so they will be able to give me apparatus that will show learners as to what is expected from them as far as practical investigation is concerned.*
>
> *I:* *So, that means that you don't get anything from provincial government?*
>
> *TS:* *I don't get from the provincial government.*
>
> *I:* *Even the district?*
>
> *TS:* *The district, I don't get anything. The HOD is not knowledgeable with Science to say the least, so he is the HOD of maths and he is also heading Science, so I'm all on my own, basically, trying to rescue the life of learners, so that they can go out there knowing exactly what is expected of them, because I have been there before and I know what is expected of them.* (Personal Communication: SCH9-TS1-I).

He comments on the fact that he has a fully stocked laboratory with expired chemicals that have never been used. This is a well-documented issue in literature where resources are provided, but without the education and training on how to properly use these resources and integrate practical demonstrations and tasks in lessons (Fricke, et al., 2008; Hattingh, Aldous & Rogan, 2007; Rogan & Grayson, 2003).

> *We have a storeroom that is packed with chemicals, useless chemicals, very old chemicals that need to be disposed or be taken to somewhere else. Yes, if our lab could just be well established, it is not a very good lab and I am teaching learners in this lab, so I'm not quite satisfied about the laboratory, because we have a shortage of classes anyway, so I have no choice but to teach in the laboratory that is not in good standard. If the lab can be in good standard, then I could always say, yes we are at least getting somewhere. So the lab must be in standard and the chemicals also must be replaced with the new ones and other apparatus, because always going to Tukkies, asking this that and the other, so we have to fix the problem of the lab.* (Personal Communication: SCH9-TS1-I).

It has been reported in the literature that the frequency of practical activities in South African Science classes are restricted by various factors. Many teachers claim that it is a lack of resources, such as equipment and laboratories, as well as large class sizes that restrict the implementation of practical work (James & Benson, 2008; Hattingh, Aldous & Rogan, 2007). However, Rogan and Aldous (2005) reported that there is no relationship between the availability of resources and the implementation of practical activities. This finding was supported by case study research in which one particular school had four laboratories, yet did not conduct any practical work. Rogan and Aldous (2005) also reported that laboratory equipment and resource kits were found in schools within their case studies that had never been unpacked which was also seen in the school observations and interviews for the secondary data analysis, particularly in the example from School 4. This finding suggests that improving the resources will make little difference unless accompanied by other interventions as well. This finding is in line with the Intervention Strategy on Science, Mathematics and Technology Education (Department of Education, 2000, p 3) comment that "throwing resources at schools that are not able to reach even a basic operational level is not a solution, but may even add to the burden of administration struggling to attain minimal standards" (Hattingh, Aldous & Rogan, 2007, p. 83).

The curriculum at the Grade 12 level is designed in such a way that learners should be able to draw inferences from practical lessons and apply their classroom-based knowledge to contexts that are new and unfamiliar. These types of application activities should be encouraged by Science teachers through the use of Science demonstrations and practical tasks. Good

classroom practices are described in the levels of Rogan and Grayson's (2003) profile of implementation. The levels progress from teacher-centred demonstrations in Level 1 to open-ended, learner-centred, investigations in Level 4 where all levels indicate competent classroom practices with regards to the implementation of practical activities and demonstrations (Rogan & Grayson, 2003).

Many types of intervention programmes have been implemented in South African schools in order to develop the use of practical activities and demonstrations in Physical Science. An example of an intervention involved pairing poorly-resourced schools with well-resourced schools where the learners were able to conduct their portfolio experiments in the well-resourced laboratories of one of the mentor schools (Fricke, et al., 2008). It was reported that that teachers did not know how to prepare their learners for practical tasks in many of the cases. As such, this type of intervention developed the teachers' PCK and SCK for practical activities because many of the teachers saw the experiment for the first time. The intervention also gave the teachers an opportunity to assess the practical ability of their learners more accurately (Fricke, et al., 2008).

In addition to resource distribution and training on how to utilise practical activities, Physical Science teachers must invest added effort and research into planning and implementing practical activities within their classes in order to fulfill the requirements of the curriculum, specifically those related to inquiry-based activities. This is a challenge for teachers because most textbooks continue to publish the traditional 'cookbook' approaches to experimentation which limits the opportunities for open investigation (Anderson, et al., 2007) unless teachers have the PCK and resourcefulness to go beyond what is found in textbooks. Lesson planning, use of resources and preparation is the fourth theme to emerge for the qualitative data.

Theme 4 – Classroom practices – lesson planning, use of resources and preparation

The fourth theme for classroom practices involves the extent of lesson planning and preparation that teachers used in the observed schools. It includes how teachers make use of available resources to prepare for various lessons and practical activities. SCH15-TS2 was one of the teachers who reported that multiple planning strategies and a variety of resources are used when preparing for lessons.

> *I'm a person who uses a lot of books. When the NCS came into place, a lot of publishers were visiting the schools, trying to promote their books, they gave us samples, so you find that I have five different textbooks for the same grade, and then I always refer to it, when I have a topic that I should teach, I check and find that in two textbooks it is not there, it is not even available, but you go to the next three and you find it and you look at the best way to teach it* (Personal Communication: SCH15-TS2-I).

This teacher also mentions that the Department of Education supplies the teachers with a framework that specifies all of the topics, content and duration of each module.

> *... the framework, that the Department is supplying, you look at the topics that you are supposed to do, how much of each the learners need to know ... and then you start preparing your lesson in relation to that* (Personal Communication: SCH15-TS2-I).

Abrahams and Millar (2008) reported that most teachers with subject specialisation did not rigorously follow schemes, textbooks or set worksheets but rather used a variety of resources and strategies. The teacher at School 15 self-reported to have completed a Further Diploma of Education which could be indicative of the level of content knowledge that the teacher is familiar with. This is contrasted by the planning strategies, resource use and preparation strategies that are used by the teacher at School 9 who completed a Postgraduate Degree and a HED.

The teacher at School 9 uses multiple planning strategies, including personal lesson planning. He adapts his lesson plans to suit the needs of his learners and communicated that he uses informal assessment to guide his teaching. His planning methods were above average and indicative of his content knowledge as discussed in the first two themes and exemplified in the case study.

> *... planning requires one to picture yourself in the shoes of the learner first. This is the initial stage of planning, then after picturing yourself, you look at the topic, you try to simplify it as much as you can, because I mean the topics are not as easy as you as a teacher can look at a topic and say this is simple. You have to find an easier way, you know, which learners will understand. So part of planning will be: go back to the shoes of the learner, picture yourself being a learner. Now take the topic you want to teach: sit down and try to read it, you as a teacher, before you can even try to design a lesson plan, you have to make sure that you plan first. You plan, you read the topic, you sort of modify the topic based on your experience and make sure you know that concepts follow each other, because books differ. So, you as a teacher must make sure that topics follow each other nicely. Then from there, it is then that you can plan the lesson looking at the outcomes, things that you want to achieve, you know, things that you want learners to achieve. After you have picked yourself up as being that learner then you can answer the question of what learners should achieve if you can be able to be in their shoes, then you should be able to be in a position of saying, "Okay, I want them to achieve this. So, this is how I am going to teach them. So, I want them to learn pH."*

> *Then, the first thing is to define what pH is, then to give them a real life example of how PH works as far as acid and base is concerned. Then from there, you can design the lesson plan looking at the topic pH, looking at what you want the learners to achieve and what are they going to use that pH for in the outside world* (Personal Communication: SCH9-TS1-I).

In planning lessons, teachers must have a clear idea of where each topic fits in to a module and have logical rationale for sequencing the lessons in a particular way. This understanding of the intended curriculum and the need for multiple planning strategies was evident in the interview with SCH18-TS1 who was able to clearly explain which topics were taught before and which would be taught after the observed lesson and why they were sequenced in that particular order.

> *… the lessons fit into the topics to such an extent that we designed a lesson for each sub-section in the whole topic… we are in chemical change and right now they are busy with acids and bases, so now in the previous lessons we talked about balancing the reactions, we talked about the types of acids that the learners are using at home. I mean the properties of acids, properties of base, types of bases that they are using at home. Then we can come to the other lesson and talk about pH. We talk about pH, then after pH, then we, I sort of make sure that one lesson covers the overall topic of chemical change… each lesson is planned very carefully, looking at what we want to achieve. And I always sensitise learners about that, saying that we must not forget what we are learning today, because we are going to use it later. We can't learn something now and just throw it somewhere else.* (Personal Communication: SCH9-TS1-I).

An essential part of planning a lesson, involves preparing the materials and equipment that are required for the implementation of the plan. The teacher at School 4 had photocopied worksheets that he prepared in advance to suit the needs of his learners and requirements of the curriculum. Specifically, photocopied notes that were prepared by SCH4-TS2 on chemical equilibrium were handed out to each learner to introduce the new topic at the beginning of the lesson. In addition to logical sequencing, preparation and in-depth planning, SCH9-TS1 used informal assessment to guide his teaching. As such, his personal planning was designed for the learners that he taught with the DoE framework in mind.

> *I only have my chalk board and my white board and those two, they obviously addresses one thing: you have to present a topic first, before you can give learners some exercises to work on. You have to present a topic to them, then get their feelings by asking them questions, relevant questions based on the relevant topic, and it is from there, it is then that you can give them some set of problems to work on, having presented that topic* (Personal Communication: SCH9-TS1-I).

Teachers with high competency in PCK will utilise personal planning in addition to the set curriculum and schemes of work. Their personal planning is modified by the level of understanding that the learners acquire, and determines what is taught and at what pace.

Sometimes prior content must be revised before proceeding with the intended curriculum; however, this should be linked with grade-appropriate work and should not take away from what is intended to be taught in each module. As mentioned earlier, Abrahams and Millar (2008) found that most teachers with subject specialisation were more likely to use a variety of resources and planning strategies and that teachers working outside of their specialist subject area are more likely to rely on routine and controllable activities which reduce the likelihood of unexpected events and questions. The distinction between different professional qualifications and planning, resource use and preparation was observed during the lesson observations for the case study schools and falls in line with existing literature. It is also important to note that pre-OBE and pre-NCS teaching in South Africa supported the strategy of following a set scheme but this is no longer the most effective method of teaching because of the various ability levels within each classroom. As such, teachers must use formative assessment strategies to guide their teaching and encourage learners to explore and question. This understanding of planning strategies, use of resources and preparation leads into the fifth theme which is the relevance of the lesson content to the Grade 12 intended curriculum.

Theme 5 – Classroom practices – relevance of the content to Grade 12

In order to cover the content of the intended curriculum, teachers must prioritise the content over that from other years. Despite the fact that knowledge in Physical Science is often based on previous learning, there is not enough time to re-teach previous grades when learners are in Grade 12. When content is re-taught, it is essential that teachers make the relevant links to Grade 12 content and that only necessary items are revised. To accommodate for the gaps in prior knowledge, extra lessons outside of designated class time are often necessary in order for the teachers to cover all of the content specified in the intended curriculum. The use of extra lessons to address gaps in prior knowledge was documented in School 15 where two teachers were required every afternoon of the week to give extra lessons to Grades 10 through 12 which places extra pressure on the teachers, *every afternoon you have to be here … if you want your work to be done well* (Personal Communication: SCH15-TS2-I).

The content of each lesson must fall in line with the intended curriculum and be implemented in an effective way using PCK, careful planning and informal assessment. Each teacher must have a clear idea of how each topic fits into the curriculum as a whole before implementing the content within the context of their class. The teacher at School 15 demonstrated a clear understanding of the intended curriculum in the following quotation.

> *Well the lessons we were talking about optics phenomena and the properties of material, how material respond to light, how it penetrates on different materials … the different materials, how can they be used to benefit the people and make life easier for them, for example the microwaves, the sound waves, the X-rays, the gamma rays and the alpha rays, they have to understand how they look like, and what they do for us as people in the environment* (Personal Communication: SCH15-TS2-I).

During the lesson observation for SCH15-TS2, the teacher used a demonstration in order to revise Grade 10 content on refraction. Although she used various resources throughout the lesson to revise prior learning, she did not link the revision work to how it is relevant to the Grade 12 content on lasers. The lesson observation notes indicated that there was little evidence of planning and that the lesson seemed to jump around and indicated shortfalls in both SCK and PCK which are exemplified in the case study for SCH15-TS2. The teacher at School 2 also spent the majority of the lesson time addressing gaps in prior learning. The observed lesson was a revision of Grade 10 work with no link made to the Grade 12 content. Wasting time teaching content that should have been taught in previous years takes away from the time that should be allocated to Grade 12 work, is seen as a detrimental aspect and one which is reflected in learner achievement. Revision of prior learning was also the main element of the observed lesson for SCH16-TS1, who indicated that she re-taught entire modules from Grade 11 during class time. *As it is the Grade 11 syllabus… but I was surprised to find that they forgot whatever we have done. Then I have to start afresh with that chapter again* (Personal Communication: SCH16-TS1-I). When revising the work, she did not link the prior content to Grade 12 work. Addressing gaps in prior knowledge by redoing entire modules would make it very difficult to cover the required, intended curriculum for Grade 12 in the allocated time. This indicates poor planning and gaps in SCK and PCK. The case study on the teacher from School 16 provides thick, rich, descriptions of the observed lessons and the interview for this teacher.

An example of a lesson that was relevant to Grade 12 content was observed in School 5 and was on lasers. According to the field notes, the teacher covered all of the content on lasers as set out in NCS and correct new terminology was introduced. The content and cognitive level of the lesson was appropriate for Grade 12 and challenged the learners. The learners seemed satisfied with how the content was implemented and showed a better understanding of the new concepts when the teacher answered their questions. The observed lesson for School 4 addressed chemical equilibrium. The lesson was well prepared; the learners were given photocopies of notes and knew exactly what the lesson was about at all times. They remained involved throughout the lesson. The observed lesson showed excellent coherence and the cognitive level of the lesson was appropriate for Grade 12 learners. The same topic was

observed in School 9 and despite a late start on the lesson, the teacher thoroughly explained the topic and gave the learners many examples. The teacher questioned the learners to informally assess their understanding. Utilising formal and informal assessment strategies is essential to guide lesson planning and preparation and to identify any gaps in prior knowledge and is discussed in the next theme.

Theme 6 – Classroom practices – formal and informal assessment strategies

It is essential for teachers to evaluate the level of understanding and knowledge acquisition that takes place in their classrooms. Informal and formal assessments give the teacher critical information that should be used to guide the pace and content of their lessons. The teacher at School 4, used informal assessment, in terms of question and answer sessions, to identify gaps in prior knowledge. These gaps were then addressed. The teacher at School 15 regularly asked questions during the observed lessons; however, the learners often did not respond, or if they did, they did so in chorus. The teacher should have waited for the learners to respond and should have asked individual learners questions to better gauge their understanding. All of the observed lessons had some type of question and answer session that was an indication of informal assessment, however, no formal assessments were observed. In the interview, the teacher at School 15 commented that she often utilises a computer program as a method of informal assessment and that the program quizzes the learners and lets them know if they are correct.

> *They can also assess themselves, the peer assessment, or self-assessment, where they work on the exercises, if they are wrong, the computer will tell them, "You are wrong" … and if they are correct, it will give them a tick to say, "You are correct". And that excites them a lot when they got the correct answer… although sometimes they are not sure how they got to the answer … you know they find they are just passing the answers around and then when they get a tick, they get so excited … but you still have to come back and check, like if I was moving around, I could pick up that, before they got to an answer, they did a lot of mistakes, so I still have to take them back to class and explain why the previous answers were wrong, why the new ones were correct* (Personal Communication: SCH15-TS2-I).

During the interview with the science teacher at School 16, it was indicated that the current content would be assessed informally, by way of peer assessment. However, the teacher should improve on this method and guide the learners on how to assess one another effectively.

> *The assessment, it was going to be a peer assessment so that they assess each other with the understanding, so I, for me I did not compile anything formally that I am going to do. It was only the peer assessment just to see whether they understand each other,*

> *they have to assess each other, so I have seen that they have done that because those who were seated they were calling to those on the board. "No, not that one, we have to correct that part"* (Personal Communication: SCH16-TS1-I).

As discussed in the literature review, it is essential that a teacher assesses learners by way of either formative and/or summative assessments. Formative assessment refers to all activities that provide the learners and the teachers with an indication of the extent of learning that has taken place and should be continuous. Formative assessments can take the form of written or verbal feedback on day-to-day interactions with the subject content. Comments given on homework or feedback during a class discussion would be examples of formative assessment, whereas, summative assessment is that which contributes to a learner's achievement mark. These assessments are formal and usually occur in the form of portfolio tasks, such as standardised tests, formal practical reports, research projects and examinations. Summative assessments provide an indication of the attained curriculum as a measure of the outcomes of both the intended and implemented curricula. None of the observed lessons or interviews indicated that the observed content would be assessed in a formal, summative assessment within the context of the classroom. Thus, the best measure of learner achievement for the observed lessons would be in the form of a standardised, summative assessment occurring in the form of secondary school exit examinations.

5.9 CONCLUSION

This chapter began with a restatement of the objectives of the study, the research questions and the key terms in Section 5.2. An analysis of the learner achievement results was conveyed in Section 5.3 and followed by a discussion of the quantitative analysis in Section 5.4. The quantitative data analysis was conducted using descriptive statistics (Section 5.4.1), frequency tables (Section 5.4.2), and Pearson correlation coefficients (Section 5.4.3). Tables were included to illustrate the key components of each of the quantitative data outputs and discussed separately. Section 5.5 served as a discussion of the teacher characteristics for the case study participants. Four case studies were offered in Section 5.6 in which the qualitative data from the Science teacher questionnaires, interviews and observations were combined in an attempt to provide thick, rich descriptions of each teacher's profile. Following this, a discussion of the themes that emerged from the observation and interview analysis were included in Section 5.7. Finally, the themes from both the Science lesson observations and Science teacher interviews were brought together and discussed in relation to the existing literature in this Section 5.8. The

conclusions for this secondary analysis research, the implications of the findings and recommendations for further research are presented in Chapter 6.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The final chapter commences with a summary of the research design in Section 6.2. Following this, a discussion of the findings according to the research questions is offered in Section 6.3. Section 6.4 serves as a reflection on related literature and the conceptual framework, whereby, Section 6.5 is a reflection on the methodology for the mixed methods secondary data analysis. The chapter concludes with recommendations for further research in Section 6.6.

6.2 SUMMARY OF RESEARCH DESIGN

The research design for the secondary data analysis was a mixed methods research design that was in line with the pragmatist paradigm (Lund, 2012; Johnson & Onwuegbuzie, 2004). From a pragmatist perspective, the researcher gave priority to the research problem and then used whatever methods were necessary to best investigate the problem (Creswell & Plano Clark, 2007, p. 23). By using a combination of both quantitative and qualitative methods, the research questions could be answered, while the respective strengths were utilised and the respective weaknesses escaped (Lund, 2012; Johnson & Onwuegbuzie, 2004; Tashakkori & Teddlie, 1998). The quantitative and qualitative methods were used concurrently with the qualitative weighted more strongly than the quantitative (QUAL + quan). Singular and multiple realities were utilised and both subjective and objective analysis of the data was used in generating and testing a hypothesis (quantitative) and generating themes (qualitative) (Lund, 2012). The views of the researcher therefore play a role in the interpretation and the researcher may choose to report formally or informally on their findings depending on the nature of the material and the extent to which it answers the research questions (Creswell & Plano Clark, 2007, p. 24). In order to minimise researcher bias, the final Grade 12 NCS pass rates for Physical Science for the 2009 cohort were not viewed by the researcher until after all of the interviews, observations and questionnaires were analysed and reported on. The quantitative examination results were only included after all other analysis and then used to answer the main research question in terms of the interconnection between teacher characteristics, classroom practices and learner achievement.

6.3 FINDINGS ACCORDING TO THE RESEARCH QUESTIONS

This section will present the research questions and then discuss each of the sub-questions in terms of the data and research findings. The main research question will then be answered, specifically, *What is the interconnection between Grade 12 Physical Science teacher characteristics, classroom practices, and National Senior Certificate Examination results in Gauteng secondary schools?*

6.3.1 What are the different categories of teacher characteristics in the FET study sample population?

Three of the five proposed categories of teacher qualification that were presented in Table 4.2 were found in the FET study sample population. The Categories of Teacher Qualifications for South Africa FET Physical Science in the sample were: Postgraduate Degree or Certificate in Education, Teaching Diploma, and Non-qualified. However, two of the expected categories that were indicated in literature were unrecorded, specifically, Non-teaching Specialist Qualification Only and Unsuitable Teacher Qualification. Each of the above mentioned categories were previously presented and discussed in Table 4.2. The recommendation for further evaluations of the categories of teacher qualifications within South African schools has been included in Section 6.6.3.

Related experience within the sample teachers ranged from 5 years to 40 years with half of the teachers having less than 12 years of experience in teaching Physical Science (see Table 5.8). As discussed in Section 5.4.3, teachers with more related experience were associated with higher learner achievement. The relationships between related experience and learner achievement have somewhat strong correlations, despite the limitations of the sample size (N=19), and indicate potential for further investigation and research. Pearson's correlation revealed a significant relationship between the total Physical Science teaching experience in years and learner achievement, specifically, pass rates, $r = 0{,}48$, $p < 0.05$.

The constructs for content knowledge were broadly reported on in the secondary analysis due to the limitations that were discussed in Themes 1 and 2 in Section 5.7. It was generally observed that the teachers in the sample schools had classroom practices that indicated potential shortfalls in both SCK and PCK. Such as, ineffective classroom management, lack of personal planning, indications of misconceptions in content knowledge, teacher-centred lessons that

generally lacked practical application. However, there were also teachers who demonstrated competency in content knowledge as depicted in the case studies in Section 5.6 and themes in Section 5.7. For example, some of the teachers showed evidence of personal planning that was guided by the curriculum documents, informal assessment activities and learner needs. The same teachers were resourceful in obtaining equipment and organising practical activities. Competency in PCK is reflected in the selection of classroom practices that are best fitted to implement the content as intend in the curriculum.

6.3.2 What are the various classroom practices that are used by teachers in each of the categories of teacher characteristics?

The various classroom practices that were used by the different categories of teacher characteristics were presented in Chapter 5 in the case studies (Section 5.6) and discussion of themes from the qualitative data analysis (Section 5.7). Four prominent classroom practices emerged as themes across the sample schools and it was widely perceived that all of the observed lessons were teacher-centred and that the learners were not given the freedom to engage in higher cognitive level questioning and exploration. The use of practical tasks and demonstrations (see Theme 3 in Section 5.7) is highly prescribed in the intended curriculum but was rarely observed in practice. Some of the teachers rationalised this shortfall as a result of a lack of resources; however, literature and observations indicated that teachers who wish to do practical tasks and demonstrations will find the resources to do so. Furthermore, the provision of resources, without context-relevant training is ineffective and has no influence on the performance of practical tasks.

A second essential classroom practice is the use of planning strategies (see Theme 4) which should be governed by a combination of the intended curriculum and the needs of the learners. The Science teachers within the sample schools reported to use schemes of work and planning documents that were provided by the Department of Education and most of the teachers were not observed to have engaged in any form of personal lesson planning or preparation. However, some of the teachers did report that they make use of informal assessment strategies to guide the sequence of their lessons. The use of informal assessment strategies was described in the case study for the Science teacher from School 9. The use of resources and preparation was also discussed in Theme 4 (Section 5.7) and illustrated that most of the teachers relied heavily on prepared resources and textbooks. According to literature, the reliance on prepared

resources has report to be associated with shortfalls content knowledge and confidence. Several teachers indicated shortages of resources and helplessness in obtaining the necessary resources to implement the curriculum as it should be. The teacher from School 9 was uniquely resourceful and mentioned that he obtained materials from the University of Pretoria. Another teacher prepared content-relevant notes for his learners and a third teacher reported to use a variety of textbooks in combination to cover the content specified in the NCS.

The content covered in several of the observed lessons lacked relevance (Theme 5) in terms what is expected at a Grade 12 level and were revision of material that should have been taught in previous grades. The revision of work was justified by the teachers in that the learners had significant gaps in their learning and did not have the foundation knowledge to cover the Grade 12 content. This knowledge gap was largely judged by informal assessment strategies by way of teacher-led questioning. However, little evidence of formal assessments was noted during the lesson observations despite the requirements set out in the national policy documents indicating that a combination of continuous assessment strategies should be utilised by teachers throughout the year.

6.3.3 To what extent are the pass rates of the Grade 12 classes for the National Senior Certificate Examination results related to each category of teacher characteristics and classroom practices?

The relationship between the pass rates of the Grade 12 classes for the National Senior Certificate Examination results and each category of teacher characteristics were determined quantitatively using Pearson correlation coefficients. A positive correlation was obtained between related experience and pass rate, with a slightly weaker relationship between teacher qualifications and pass rates. From the qualitative analysis of the case studies, it was indicative that teachers who demonstrated higher levels of competency in terms of SCK and PCK also had higher pass rates. This finding was inconclusive and is included in the recommendations for future research in Section 6.6.3. Generally, the teachers with higher levels of professional qualifications and teaching certification had better classroom practices. They utilised a variety of planning methods, resources, practical work and demonstrations. There was one unqualified teacher in the study who also possessed a high level of related experience. However, the pass rates for this teacher's classes were lower than for classes taught by teachers with less experience who had obtained postgraduate qualifications in education.

Drawing on the three sub-questions operationalized for the study, the main research question can be addressed. As explained in the conceptual framework (see Section 3.3), and supported by the mixed methods results, teacher characteristics do influence the types of classroom practices that teachers select. The results from the secondary analysis indicate that postgraduate qualifications in education are related to higher competency in PCK and SCK which is reflected in the types of classroom practices that these teachers use and higher learner pass rates on NCS examinations. It was also observed that un-qualified teachers with more experience than their qualified colleagues had lower pass rates despite the Pearson's correlations that reported a positive relationship between related experience and learner pass rates. Thus, teacher professional qualifications, in conjunction with experience, are an influential factor on classroom practices and learner achievement. This interconnection was supported by the case study results and indicates a need for further research.

6.4 REFLECTION ON LITERATURE AND CONCEPTUAL FRAMEWORK

This section reflects on the results and how they relate to what exists in literature, specifically that which was discussed in Chapter 2, the literature review. This section also reports on the research findings and how they relate to the existing conceptual framework discussed in Chapter 3 and exemplifies aspects of the framework that need to be modified after taking into account the findings from the secondary data analysis.

The key concepts within the above framework were defined in Chapter 1 and have been included again in this section for the purpose of increased clarity. Teacher characteristics were defined as: teacher qualifications (Bolyard & Moyer-Packenham 2008; LaTurner, 2002; Darling-Hammond, 2000); related experience (James & Benson, 2008; Onwu, 2000); subject content knowledge (SCK) and pedagogical content knowledge (PCK) (Alder, et al., 2009; Beets, 2009; van Dijk & Kattmann, 2007). Classroom practices were defined as all of the activities and learning strategies that teachers use in their lessons. Learner achievement in terms of this research referred to the performance of Grade 12 Physical Science learners on the 2009 National Senior Certificate Examinations and was measured in terms of the pass rate for each school.

The conceptual framework used for the research study is included below (originally presented in Chapter 3 as Figure 3.3). The framework, modified from Howie and Scherman (2008b),

investigates the interconnection between teacher characteristics, classroom practices and learner achievement.

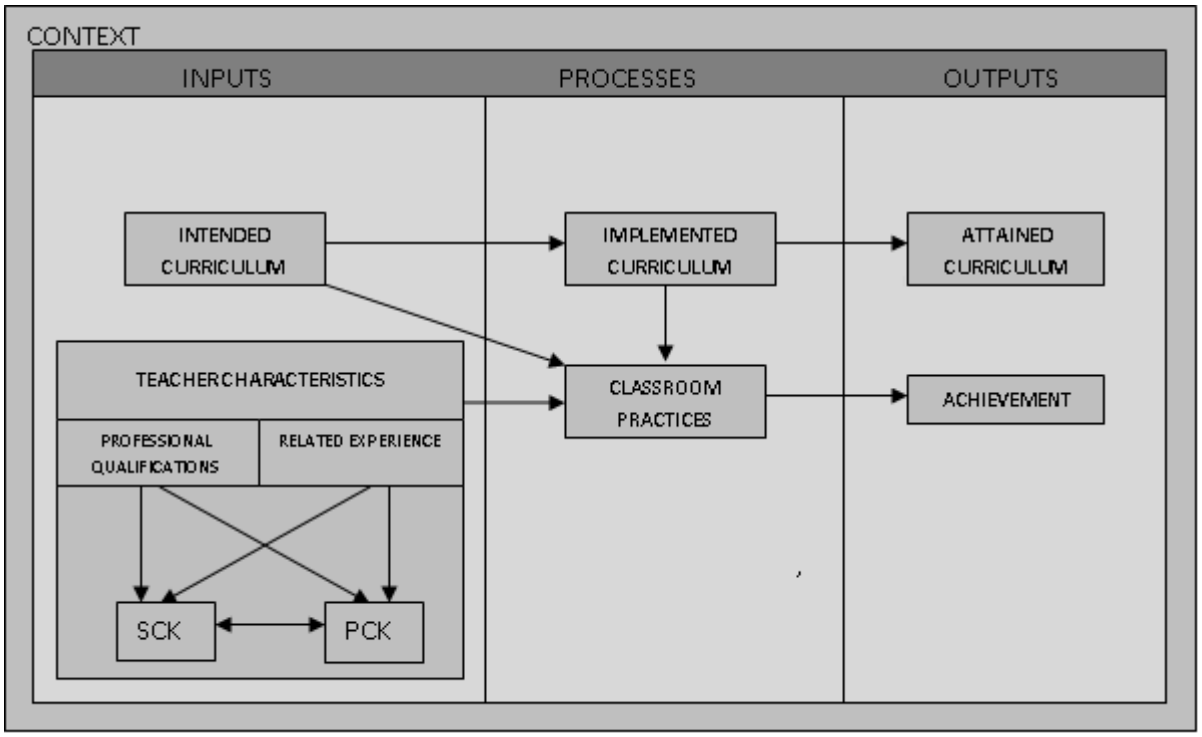

Figure 6.1 – Revised conceptual framework the investigation of the interconnection of teacher characteristics, classroom practices and learner achievement in Physical Science (modified from Howie & Scherman, 2008b, p.128).

The existing conceptual framework has a strong theoretical foundation; however, the constructs for ‘interest in STEM careers’ and ‘ attitudes’ were removed because it has been documented that many learners in South Africa enjoy Science and aspire to enter into STEM careers but do not have the achievement results to do so (Howie & Scherman, 2008). In addition, the themes that emerged from the qualitative data did not represent these two constructs. Thus, the remaining conceptual framework could be used as is, in conjunction with the recommendations for future research that have been included in Section 6.7. This is supported by the research findings from the secondary data analysis and rationalised by the fact that they fall in line with existing literature and existing conceptual framework.

6.5 REFLECTION ON THE METHODOLOGY

This section discusses the limitations of the secondary analysis study in relation to the planned methodology and where changes needed to be implemented. This section with discuss the strengths in the concurrent mixed-methods design, the strengths and weaknesses in the data and analysis methodology, sample methods, and measures of learner achievement.

A mixed-methods research design was selected to answer the main research question because it fits the pragmatic stance, specifically, to identify the interconnection between teacher characteristics (such as, formal qualifications, experience, and knowledge), classroom practices and learner achievement. A concurrent mixed methods design was used for the secondary data analysis. Specifically, quantitative and qualitative data were collected and used in conjunction to provide a detailed description and to best understand the research problem (Creswell & Plano Clark, 2012; Lund, 2012). However, the qualitative data took priority. This was useful because quantitative data provides an opportunity to look at numerous Grade 12 teachers with regards to their qualifications and the achievement results obtained by the learners they teach. It also allowed detailed exploration of the various types of classroom practices that are used by these teachers through the personal account of the teachers in teacher interviews and through the lesson observations of these teachers. The extent to which relationships occur between teacher characteristics, classroom practices and achievement were analysed in terms of correlations. As such, a concurrent mixed methods design was most fitting to address the research questions using both quantitative and qualitative data collection and analysis.

The first research question was to develop a classification scheme and identify the categories of qualifications within the sample population. One problem with the scheme was that the categories for ‘Non-teaching Specialist Qualification Only’ and ‘Unsuitable Teacher Qualification’ could not be identified in the data set due to the limitations of the primary questionnaire items. It would have been beneficial to have items that identify teachers who are not formally qualified teachers but possess significant experience or Science specialisation such as a B.Sc. or equivalent degree, and teachers without phase appropriate teaching qualifications (for example, Junior Primary Teacher Certificate (JPTC) or Senior Primary Teacher Certificate (SPTC)).

A shortfall of using Rogan and Grayson's (2003) profile of implementation for this secondary analysis was that it was contextualised for natural Science as a junior college level, rather than for Physical Science at a FET level. As such, some of the elements were not evident in the lesson observations. This could be due to phase or gaps in implementation and should be further investigated in future research. Also, Rogan and Grayson's (2003) profile of implementation did not address teachers who are 'implementing' below the standard of Level 1 and the Science Lesson Observation System (SLOS) (Gwimbi & Monk, 2003) provide the equivalent level of detail required to evaluate the classroom practices that relate to FET Physical Science as was intended in the methodology.

The intended methodology proposed to examine the data from a larger sample in order to increase the validity and reliability of the results; however, due to the high prevalence of incomplete data sets, this was not possible. Reflecting on the methodology for the sample selection, one benefit of using primary sample set was that it provided access to a relatively large data set and very detailed insights for 18 different schools. The limitations in using the full data set, as initially intended in the methodology was hindered by incomplete data sets due to the large sample population and difficulty in getting all phases of data collection for each participant over the course of the year. It also would have been beneficial to have a more focused sample selection and to focus on teachers within similar contexts but with differing qualifications. It was good to have the diversity across all of the quintiles, but actually being able to focus on one quintile and within one type of contextual environment, might have been beneficial in uncovering the classroom practices associated with each category of teacher characteristic.

With regards to the instruments that were presented in the methodology chapter and utilised in the secondary data analysis, it would have been beneficial to have questionnaire items that involved more precise professional qualification specification. Shortfalls in utilising the qualitative instruments, specifically the interview and observation data, only involved the incomplete data sets and it would have been beneficial for the secondary analysis to have been done on a larger number of teachers who completed all of the instruments.

Finally, a major obstacle for the secondary data analysis occurred because of difficulty in obtaining the individual learner results for each school for the Physical Science 2009 NCS final examinations. The results were requested from the GDE in writing by the CEA and the

researcher; however, the results were not provided within the deadlines of the secondary analysis and thus, the pass rates had to be used as an alternative measure of learner achievement. More detailed records of the observations in terms of assessment practices that occurred within the classes that were selected for observations.

The mixed data analysis methods (QUAL + quan) were sufficient in answering the research questions. Due to the nature of the data, it was fitting to use descriptive statistics, frequencies, correlations and content analysis to identify the interconnection between teacher characteristics, classroom practices and learner achievement.

6.6 RECOMMENDATIONS

This section will discuss recommendations for policy development and implementation in Section 6.6.1 and recommendations for teacher training programs, both PRESET and INSET in Section 6.6.2. Finally, Section 6.6.3 will discuss recommendations future research investigating the interconnections between teacher characteristics, classroom practices and learner achievement. Overall, there are many possible recommendations for future research that would provide policymakers, administration, higher education institutions and researchers with methods that would provide greater insight into the interconnections between science teacher characteristics, classroom practices and learner achievement.

6.6.1 Recommendations for Policy Development and Implementation

The majority of teachers in the secondary analysis did not feel that they were adequately prepared to teach C2005 and OBE prior to the implementation of the curriculum. The cascade approach for INSET was not sufficient to provide the teachers with adequate support in terms of how the intended curriculum should have been implemented. Policy developers and management structures should attempt to identify master teachers who have exemplary classroom practices and teacher characteristics that teach within the context of each cluster of schools. By doing this, cluster groups can be created so that the teachers can receive regular, relevant support in the context in which they teach. Curriculum documents should be designed in such a way that they address the needs of the nation as a whole and with the intention of encouraging and preparing learners to enter into STEM careers. Interventions should also be put into place to minimise the gaps in SCK and PCK in the existing teacher population.

6.6.2 Recommendations for PRESET and INSET Programmes

Recommendations for PRESET programmes involve that the programmes are looked at in terms of the level of PCK and SCK teachers have when they enter and exit the programme. Identifying levels of SCK and PCK would be informative in advising INSET and specific routes of PRESET that would allow teachers to enhance their current levels and develop in terms of Rogan and Grayson's (2003) Profile of Implementation. For example, if teacher classroom practices are researched further to 'link' to learner achievement (a current international focus in education) then teachers who have high PCK and low SCK can be targeted to attend workshops focused on SCK. Whereas, teachers with high SCK and low PCK can attend specialist workshops with regards to increasing PCK. In such situations, follow-up classroom observations could look at changes in these teacher's classroom practices to see if they were effective in enhancing the teacher characteristics and classroom practices. If this is the case, then professional qualifications/classroom practices would not 'lock' teachers into a specific category of practice, but rather narrow the focus of intervention to make it relevant and save the stakeholders money and resources.

6.6.3 Recommendations for Future Research

The findings from the secondary analysis suggest that there is a need for future research that will further investigate the interconnections between teacher characteristics, classroom practices and learner achievement. A recommendation for future research is to look at the relationship between teacher qualifications and the type of school, perhaps based on quintiles and/or infrastructure checklists. This is relevant because Darling-Hammond (2000), LaTurner (2002) and Howie and Scherman (2008) all reported that under-qualified teachers are more likely to teach in disadvantaged schools which ties into the context of the conceptual framework with regards to the inputs – processes – outputs chain of reasoning. It is important to investigate where the clusters of unqualified teachers are most pre-dominant so that more intensive in-service training (INSET), clustering and moderation can be directed towards these teachers. The findings of Howie's research "may also suggest that part of the solution in developing the sound knowledge and skills base of learners in South Africa lies in interventions related to language at both the learner level and the teacher level" (Howie et al., 2008a, p.41). This influence of language on classroom practices and learner achievement was not part of the research question and is also a recommendation for future research. It is also valuable to identify language preferences and context along with pre-service (PRESET) classification when developing INSET so that it is specific to these groups of teachers and the context in

which they teach. “The underlying assumption is that if we change teachers’ perceptions and understanding of Science then their knowledge will be translated to the learners and eventually be evident in learner assessment results” (James, 2008, p.3). Additionally, it is recommended that future research should use a larger sample to increase the amount of complete data sets in order to better test the conceptual framework. The larger sample would allow for greater exploration quantitatively.

A second recommendation would be to include the teachers in the agreement for data collection, in addition to the order from the GDE. This may increase the teacher’s understanding and commitment to the study. Having a committed sample of teachers who could provide well recorded class lists, would make it easier to make the interconnections between teacher characteristics, classroom practices and learner achievement results.

A third recommendation would be to intensify the level of training that is given to fieldworkers with regards to data collection, interview technique and filing methods. Some of the fieldworkers did not follow the prescribe interview protocol which discredited the analysis of the interviews and decreased the amount of useful qualitative data for analysis. In terms of interview protocol, set questions in terms of specific qualifications, when they were obtained and where the teachers qualified would also be valuable. This is due to the historical past inequalities in teacher education (Onwu & Mogari, 2004) and variable training for Mathematics and Science teachers in the previous political dispensation (Ono & Ferreira, 2010). As such it would be useful to identify the fractions of the population that entered into the profession during various time frames in South Africa. Currently, all racial groups have equal access to universities and current qualifications in education combine practice, pedagogy and subject specialization (Reddy, 2009). The time frames that have the most distinctive features in teacher education in South Africa are: prior to 1994 (The Apartheid Era) (Kachelhoffer, 1995); post-1994 (period of huge educational and political restructuring – changes occurred rapidly and did not permit time for teachers to adjust to them – issues of rebellion against change in teaching strategies (i.e. rote learning, etc.); and post-2005 (Outcomes-Based Education and the most current curriculum approach and structure. Most of these teachers would have undergone most of their elementary and secondary school post-1994, thus should have been taught in a similar way to how they are expected to teach).

A fourth recommendation for further research is to cross-reference the professional qualifications with both SAQA and SACE data for each of the teachers. The data in the primary study was all self-reported and should be validated by concrete certificates in future studies. It is important to note that teachers having qualifications in non-Science areas are categorised as either "non-qualified" or "non-specialist teaching qualified only", this data was not attainable in the primary study and is a recommendation for future research. In the future, it is recommended that the GDE or schools provide the certified documentation for each teacher's qualifications.

A fifth recommendation for future research is related to learner achievement and would be to obtain individual final NCS examination marks for each learner on a class list so that they can be linked to each individual teacher, specifically, teacher characteristics and classroom practices.

In addition to the NCS results, it would also be useful to look at the National Benchmark Tests (NBT) results for each learner associated with each teacher. The NBT is an assessment for prospective first year entry learners into Higher Education and was designed to measure a writer's levels of proficiency in Academic Literacy, Quantitative Literacy and Mathematics as related to the demands of tertiary study. The NBT also provides information to assist in the placement of learners in appropriate curricular routes (e.g. regular, augmented, extended, bridging or foundation programmes) and with the development of curriculum for Higher Education programmes. In addition, it assists Higher Education to interpret school-leaving results, such as those of the National Senior Certificate (NSC) (www.nbt.ac.za).

A final recommendation for future research would be to assess the learners after the implementation of Curriculum and Assessment Policy Statements (CAPS) as an alternative to c2005. "The new Curriculum and Assessment Policy Statements (CAPS) will repackage the existing curriculum into the general aims of the South African curriculum, the specific aims of each subject, clearly delineated topics to be covered per term and the required number and type of assessments, also per term. In this way, outcomes will be absorbed into more accessible aims, and content and assessment requirements will be spelt out more clearly. Topics and assessments to be covered per term are being aligned to available time allocations per subject" (Motshekga, 2010).

6.7 CONCLUSION

The final chapter included a summary of the research design in Section 6.2 and a discussion of the findings according to the research questions were presented in Section 6.3. Section 6.4 served as a reflection on related literature and the conceptual framework, whereby, Section 6.5 provided a reflection on the methodology. The chapter concluded with Section 6.6 which presented various recommendations for policy development and implementation, teacher training programmes, and for future research.

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APPENDIX A
INSTRUMENT – SCIENCE TEACHER QUESTIONNAIRE

Centre for Evaluation & Assessment

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Gauteng Department of Education Implementation of the Mathematics and Physical Science Curriculum in the FET Phase:

Phase I Data Collection

SCIENCE TEACHER QUESTIONNAIRE

Name of School	
Name of Teacher	
Date	
Name of Fieldworker	

Code: (Office use only)

About the Project

The Gauteng Department of Education (GDE) has committed itself to the evaluation of the implementation of the Further Education and Training (FET) Mathematics and Physical Science curriculum during 2009. This evaluation will be undertaken by the Centre for Evaluation and Assessment (CEA) at the University of Pretoria on behalf of the GDE and have the following objectives in mind:

- How schools are implementing the curriculum in Mathematics and Science in Grades ten to twelve;
- Whether teachers understand the NCS and how to teach the topics specified therein;
- How teachers are implementing the curriculum in the classroom;
- Whether methodologies used to teach the curriculum are appropriate and relevant;
- Whether teaching methodologies and assessment standards are pitched at the appropriate cognitive levels;
- What the extent of curriculum coverage is;
- How learners are performing against new assessment standards and to what extent these learners are able to show evidence of attainment of the assessment standards for these two learning areas in comparison to what expected standards are;
- What the issues are that contribute to poor implementation;
- What kinds of support are deemed necessary from the GDE to facilitate the teaching of Mathematics and Science in these Grades;
- What lessons teaching institutions can learn for teaching development programmes.

We appreciate your time in participating in this research and being willing to answer this questionnaire. Your assistance will contribute to the success of this important research project.

Instructions

In this booklet, you will find questions about yourself and your learners. For each question, you should choose the answer you think is best.

- Read each question carefully, and pick the answer you think is best.
- Fill in the circle next to your answer.
- If you decide to change your answer, draw an **X** through your first answer and then fill in the circle next to or under your new answer.

Please note that all responses are confidential. Names on this questionnaire will be used for administrative purposes only.

Thank you

1. About You

1.1 Are you male or female?

Male O
Female O

1.2 How old are you?

Younger than 25 years O
25 to 29 years O
30 to 39 years O
40 to 49 years O
50 to 59 years O
60 years or older O

1.3 What is the highest level of formal education you have completed?

Fill in one circle only

Did not complete Grade 12/ Standard 10 O
Finished Grade 12/ Standard 10 O
Finished College, Post Matric Certificate O
Finished Technikon O
Finished First Degree or Diploma O
Finished Post Graduate Degree: Honours O
Masters O
PhD O

1.4 Do you have a teaching diploma or certificate?

*Fill in **one** circle only*

Yes O
No O

If No, go to 1.6
If Yes, continue with 1.5

1.5 What type of diploma or certificate do you hold?

Primary Teacher certificate (PTC)	
Junior Primary Teacher certificate (JPTC)	O
Senior Primary Teacher certificate (SPTC)	O
Secondary Education Diploma	
3-year College of Education Diploma	O
4-year College of Education Diploma	O
Advanced Certificate of Education (ACE)	O
Further diploma of Education	O
Postgraduate University or Technikon	
Univ/Tech Higher Education Diploma (HED)	O
Post Graduate certificate of Education (PGCE)	O
Other	O

If other, please give details

_____

_____

_____

_____

1.6 By the end of this school year, how many years will you have been teaching altogether?

_____ years

Please round to the nearest whole number

1.7 By the end of this school year, how many years in total will you have been teaching Science?

_____ years

Please round to the nearest whole number

1.8 By the end of this school year, how many years in total will you have been teaching the FET phase specifically?

_____ years

Please round to the nearest whole number

1.9 In the past two years, how many hours in total have you participated in-service/professional development workshops or seminars that dealt directly with Science teaching (e.g. instructional methods)?

*Fill in **one** circle only*

a) None O
b) Less than 6 hours O
c) 6-15 hours O
d) 16-35 hours O
e) More than 35 hours O

1.10 How much do you agree with the following statements?

*Fill in **one** circle for each line*

		Agree a lot	Agree a little	Disagree a little	Disagree a lot
a)	I am content with my profession as a teacher	O	O	O	O
b)	I am satisfied with being a teacher at this school	O	O	O	O
c)	I would describe the teachers at this school as a satisfied group	O	O	O	O
d)	I had more enthusiasm when I began teaching than I have now	O	O	O	O
e)	I make a difference as a teacher	O	O	O	O
f)	I enjoy teaching Science	O	O	O	O
g)	I enjoy teaching Science using the NCS	O	O	O	O

2. Your Classroom and Teaching

2.1 According to your <u>previous</u> experience of teaching at this school, how would you describe the level of Science competence of the <u>current</u> Grade 10, 11 and 12 learners in this school?

*Fill in **one** circle only*

a) Most are above average O
b) Most are average O
c) Most are below average O
d) Levels of competence vary greatly O

2.2 Where do you prepare materials for teaching Science?

*Fill in **one** circle only*

Only at home	O
Mostly at home	O
About equally at home and at school	O
Mostly at school	O
Only at school	O
I do not prepare materials for teaching	O

2.3 In a typical school week, what percentage of your time in class with learners do you devote to the following activities?

Write a percentage for each so that it totals 100%

a) Teaching the class as a whole	_____%
b) Working with individual learners	_____%
c) Working with small groups	_____%
d) Engaging learners in problem solving activities	_____%
e) Administrative duties (e.g., attendance)	_____%
f) Maintaining discipline	_____%
	Total = 100 %

2.4 In order to facilitate your teaching, which of the following do you have?

*Fill in **one** circle for each line*

	Yes	No
a) A copy of the National Curriculum Statement	O	O
b) An annual work schedule	O	O
c) A term plan	O	O
d) A weekly plan	O	O
e) A lesson plan	O	O
f) A timetable	O	O
g) A class list for each class taught	O	O
h) A mark schedule/progress chart	O	O

2.5 When you teach Science and/or do Science activities, how often do you organize learners in the following ways?

*Fill in **one** circle for each line*

	Always or almost always	Often	Sometimes	Never
a) I teach Science as a whole-class activity	O	O	O	O
b) I create same-ability groups	O	O	O	O
c) I create mixed-ability groups	O	O	O	O
d) I use individualised instruction for teaching	O	O	O	O
e) Learners work independently on an assigned plan or goal	O	O	O	O
f) Learners work independently on a goal they choose themselves	O	O	O	O

2.6 What do you usually do if a learner begins to fall behind in Science?

*Fill in **one** circle for each line*

	Yes	No
a) I wait to see if performance improves with maturation	O	O
b) I spend time working on content individually with that learner	O	O
c) I have other learners work with the learner having difficulty	O	O
d) I have the learner work in the regular classroom with a Teaching aide/teaching assistant	O	O
e) I suggest the learner attend extra lessons (e.g. tutorial sessions, Saturday schools)	O	O
f) I assign extra work to assist the learner's progression	O	O
g) I ask the parents to help the learner	O	O

2.7 If you teach *Grade 10 Science*, how ready do you feel to teach each of the following topics?

*Fill in **one** circle for each line*

	Not Ready	Ready	Very Ready
a) Motion in 1 dimension	O	O	O
b) Gravity and mechanical energy	O	O	O
c) Transverse pulses and waves	O	O	O
d) Geometrical optics	O	O	O
e) Magnetism	O	O	O
f) Electrostatics	O	O	O
g) Electric circuits	O	O	O
h) Materials classification	O	O	O
i) Atoms and molecules	O	O	O
j) Physical and chemical change	O	O	O
k) Intermolecular forces	O	O	O
l) Natural cycles	O	O	O
m) Ions and aqueous solutions	O	O	O

2.7.1 If you answered that you are not ready for any of the topics mentioned above, please indicate why you are not ready.

_____

_____

_____

_____

_____

2.8 If you teach *Grade 11 Science*, how ready do you feel to teach each of the following topics?

*Fill in **one** circle for each line*

	Not Ready	Ready	Very Ready
a) Forces	O	O	O
b) Momentum and impulse	O	O	O
c) Optical instruments	O	O	O
d) Sound	O	O	O
e) Electrostatics (forces, fields, potential, capacitance)	O	O	O
f) Electromagnetism	O	O	O
g) Electric circuits (resistance, networks, wheatstone bridge)	O	O	O
h) Semiconductors and junctions	O	O	O
i) Chemical bonds and molecular shape	O	O	O
j) Atomic nuclei	O	O	O
k) Ideal gases and thermal properties	O	O	O
l) Quantitative chemistry	O	O	O
m) Chemical energy	O	O	O
n) Reaction types	O	O	O
o) Lithosphere: mining and energy	O	O	O
p) Atmosphere: chemical and environment	O	O	O

2.8.1 If you answered that you are not ready for any of the topics mentioned above, please indicate why you are not ready.

_____

_____

_____

_____

_____

2.9 If you teach *Grade 12 Science*, how ready do you feel to teach each of the following topics?

*Fill in **one** circle for each line*

	Not Ready	Ready	Very Ready
a) Motion in 2 dimension	O	O	O
b) Work power and energy	O	O	O
c) Doppler effect	O	O	O
d) Colour	O	O	O
e) Diffraction and interference	O	O	O
f) Wave nature of matter	O	O	O
g) Electrodynamics	O	O	O
h) Electronics: circuits	O	O	O
i) Electromagnetic radiation	O	O	O
j) Optical properties of matter	O	O	O
k) Organic molecules	O	O	O
l) Mechanical properties of matter	O	O	O
m) Organic macromolecules	O	O	O
n) Rate and extent of reactions	O	O	O
o) Electrochemical reactions	O	O	O
p) Chemical industry	O	O	O

2.9.1 If you answered that you are not ready for any of the topics mentioned above, please indicate why you are not ready.

_____

_____

_____

_____

_____

3. Assessment in your Classroom

3.1 How much emphasis do you place on the following sources to monitor learners' progress in Science?

*Fill in **one** circle for each line*

	Major emphasis	Some emphasis	Little or no emphasis
a) Short tests at the beginning of the lesson	O	O	O
b) Full period class tests	O	O	O
c) Screening learners' workbooks during the lesson	O	O	O
d) National or regional standardised achievement tests	O	O	O
e) Your professional judgment	O	O	O
f) Reviewing learners' homework	O	O	O

3.2 How often do you use each of the following to assess learners' performance in Science?

*Fill in **one** circle for each line*

	At least once a week	Once or twice a month	Once or twice a year	Never
a) Multiple-choice questions	O	O	O	O
b) Short-answer written questions	O	O	O	O
c) Paragraph-length written responses	O	O	O	O
d) Oral questioning of learners	O	O	O	O
e) Learners give an oral summary/report of their work	O	O	O	O
f) Meeting with learners to discuss what they have learnt and work they have done	O	O	O	O

3.3 How do you use this information (from question 3.2)?
*Fill in **one** circle for each line*

	Yes	No
a) To assign marks or Grades	O	O
b) To adapt my instruction	O	O
c) To inform parents of learner progress	O	O
d) To identify learners in need of remedial instruction	O	O
e) To group learners for instruction	O	O
f) To provide data for national or local monitoring	O	O
g) To put into learners' portfolios	O	O

3.4 How much are portfolios (collection of samples of learners work, etc.) a part of your assessment of learners' progress in Science?
*Fill in **one** circle only*

Major source	O
Supplementary source	O
Do not use at all	O

3.5 Indicate to what extent you agree with each of the following statements.
*Fill in **one** circle for each line*

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
a) I record various assessment types to track learner performance	O	O	O	O
b) I find that the requirements of assessment impacts negatively on the time available for teaching and learning	O	O	O	O
c) I make use of feedback on assessment to support individual learners	O	O	O	O
d) The results of the external examination is a true reflection of my learners' attainment of the learning outcomes	O	O	O	O
e) Assessment provides me with useful evidence of learners' understanding which I use to plan subsequent lessons	O	O	O	O

*Fill in **one** circle for each line*

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
f) Learners are told how well they have done in relation to their own previous performance	O	O	O	O
g) I identify learners' strengths and advise them how to develop them further	O	O	O	O
h) Learners are encouraged to view mistakes as valuable learning opportunities	O	O	O	O
i) I use questions mainly to elicit reasons and explanations from learners	O	O	O	O
j) Learner effort is seen as important when assessing their learning	O	O	O	O
k) The next lesson is determined more by the prescribed curriculum than by how well learners did in the last lesson	O	O	O	O
l) The main emphasis in my assessments is on whether learners know, understand or can do prescribed elements of the curriculum	O	O	O	O
m) I use questions mainly to elicit factual knowledge from my learners	O	O	O	O
n) I consider the most worthwhile assessment to be assessment that is undertaken by the teacher	O	O	O	O
o) Assessment of learners' work consists primarily of marks and Grades	O	O	O	O

3.6 Indicate to what extent you agree with each of the following statements.

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
a) Learners are given opportunities to decide on their own learning objectives	O	O	O	O
b) I provide guidance to help learners assess their own work	O	O	O	O
c) I provide guidance to help learners to assess one another's work	O	O	O	O
d) I provide guidance to help learners assess their own learning	O	O	O	O
e) Learners are given opportunities to assess one another's work	O	O	O	O

4. Interaction

4.1 For the typical Grade 10, 11 or 12 learner in your class, how often do you…

*Fill in **one** circle for each line*

	At least once a week	Once or twice a month	Once or twice a year	Never
a) Meet or talk with the learner's parents to discuss his/her progress in Science	O	O	O	O
b) Send a progress report on the learner's progress home to his/her parents	O	O	O	O
c) Discuss individual learners' progress with the HoD	O	O	O	O
d) Discuss individual learners' progress with the principal	O	O	O	O

4.2 Rate the importance of each of the following factors in informing your teaching.

*Fill in **one** circle for each line*

	Low	Rather low	Neutral	Rather high	High
a) The curriculum	O	O	O	O	O
b) The textbook	O	O	O	O	O
c) Learners' progress through assessment	O	O	O	O	O
d) Informal classroom assessment	O	O	O	O	O
e) Consulting with colleagues	O	O	O	O	O
f) Departmental circulars	O	O	O	O	O
g) Support from subject advisors	O	O	O	O	O
h) Cluster meetings	O	O	O	O	O
i) Teacher workshops	O	O	O	O	O

4.3 How much do you agree with the following statements?

*Fill in **one** circle for each line*

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
a) I have time during the regular school week to work with my colleagues on the Science curriculum and teaching	O	O	O	O
b) Science teachers in this school regularly observe each other when teaching as part	O	O	O	O

of sharing and improving instructional strategies

5. National Curriculum Statement

5.1 How well do you think teaching with the NCS allows you as a teacher to prepare learners to:

*Fill in **one** circle for each line*

	Not at all	A little	Some	Quite a lot	A lot
a) Enter Science /engineering/ medicine at university	O	O	O	O	O
b) Participate in public debate on tensions between Science and society	O	O	O	O	O
c) Make informed decisions	O	O	O	O	O
d) Evaluate information in the media	O	O	O	O	O

5.2 Rate the importance of each of the following methodologies in the successful implementation of the NCS for the learning of Science:

*Fill in **one** circle for each line*

	Low	Rather low	Neutral	Rather high	High
a) Group work	O	O	O	O	O
b) Cooperative learning	O	O	O	O	O
c) Direct instruction	O	O	O	O	O
d) Project work	O	O	O	O	O
e) Individual work	O	O	O	O	O
f) Drill and practice	O	O	O	O	O
g) Problem solving	O	O	O	O	O
h) Hands on practical activities	O	O	O	O	O
i) Teacher demonstration	O	O	O	O	O

THANK YOU FOR YOUR TIME!

APPENDIX B
INSTRUMENT – SCIENCE TEACHER INTERVIEW PROTOCOL

Centre for Evaluation & Assessment

100 1908 - 2008

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Gauteng Department of Education Implementation of the Mathematics and Physical Science Curriculum in the FET Phase

Phase I Data Collection

TEACHER INTERVIEW (SCIENCE AND MATHS)

Name of School	
Name of Teacher	
Subject	
Date	
Name of Fieldworker	

Code: (Office use only)

Introduction

I appreciate your letting me observe your class. I have some questions I'd like to ask you related to this lesson. Would you mind if I taped the interview? It will help me stay focused on our conversation and it will ensure I have an accurate record of what we discussed.

Please get the following information about the interview:

1. *Time of interview*
2. *Duration of interview (in minutes)*

---

1. About the Science/mathematics teacher

- Tell me about why you became a teacher?

  Use the following probes if necessary:

  - *Why specifically Maths/Science?*
  - *What is the most important thing you want your learners to achieve in your Science/Maths class?*

- How, if at all, has the way you feel about teaching changed over the years?

---

2. About the learners

- Tell me about the learners in your class.

  Use the following probes if necessary:

  - *Language*
  - *Ability*
  - *Special needs*
  - *Attendance*
  - *Discipline*
  - *Motivation*

- How do you deal with teaching Maths /Science to these learners?

3. About the NCS

- [*If only teaching for a short time*] Please share your thoughts about teaching with the NCS.

OR

- [*If teaching for a while*] Please share your thoughts about teaching with the NCS compared to the old curriculum [what has changed, is it better or worse].

- What sort of support are you receiving for implementing the NCS?

  Use the following probes if necessary:

  - *Provincial*
  - *District*
  - *School*
  - *From the school principal*
  - *From the subject HoD*
  - *Resources*

- What sort of support do you still need?

- If you could, how would you change the way support is provided for implementing the NCS?

4. Questions specific to the observed lesson (if applicable)

- Tell me a little bit about the lesson I have just observed.
- *Planning* - Tell me about the planning/preparation that you needed to do for this lesson.
- *Teaching strategy* – I noticed that you used …… [group work, learners working in pairs, a presentation, etc] …… to teach this topic. Tell me about why you chose this particular teaching strategy for this lesson.
- In your opinion, which parts of the lesson you think worked well or did not work well?

- *Sequencing* – How does this lesson fit into the whole topic? (Tell me about the lessons before this one and those coming after)

- *Assessment* - Will the content of this lesson form part of your assessment? If so, in what way?

If applicable, ask if you can have a copy of the instructional materials used for this lesson? [Specify what you would like to have copies of, if necessary.]

Thank you for your time. If I have any additional questions or need clarification, how and when is it best to contact you?

APPENDIX C
INSTRUMENT – CLASSROOM OBSERVATION SCHEDULE

Centre for Evaluation & Assessment

100 1908 - 2008

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Gauteng Department of Education Implementation of the Mathematics and Physical Science Curriculum in FET Phase

Phase I Data Collection

CLASSROOM OBSERVATION SCHEDULE

Name of School	
Name of fieldworker	
Subject observed	
Grade observed	
Name of Teacher	
Date of observation	
Expected number of learners in class	
Actual number of learners in class	

Code: (Office use only)

PHYSICAL CLASSROOM ENVIRONMENT

Please use this section to get a sense of the teaching and learning environment in which the lesson is being taught. Use the space at the bottom for any additional comments which you think might be relevant.

	YES	NO
1.1 Are there signs of vandalisms		
1.2 Are the walls and floors of the classroom clean		
1.3 Is the room adequately ventilated		
1.4 Is the temperature of the room conducive to learning		
1.5 Is the light in the classroom adequate		
1.6 Is the writing board/visual aids visible to all learners		
1.7 Is there enough space between desks and tables for the teachers and learners to move around		
1.8 Are there enough chairs/work spaces for all learners		

Comments on the physical environment:

2. THE LESSON STRUCTURE

2.1 What topic is dealt with in this lesson (be as specific as possible)?

2.2 How is the lesson introduced? Include how much time was spent on the introduction and what both the learners and the teacher were doing during the introduction.

2.3 How is the class time spent during the lesson (both teacher and learners)? Give a full description of what happens during the lesson in as much detail as possible

2.4 How is the lesson concluded? Be specific about the time that the teacher spent on concluding the lesson and what both the teacher and the learners did during this time.

3. DESCRIPTION OF THE TEACHING AND LEARNING IN THIS LESSON

Please observe and report on the following aspects of the lesson:

3.1 **Language** used in this lesson (language of instruction, language learners use to address the teacher, language learners use to speak to each other).

3.2 Use of **questioning** (who asks questions, who answers) during this lesson.

3.3 Use of **assessment** during this lesson (informal and formal).

3.4 **Teacher resources** (e.g. text book, OHP, blackboard, charts) that the teacher has available and that the teacher uses in this lesson.

3.5 Use of **learner resources** by the learners (text books, stationary, calculators) that are used in this lesson. If it is a Science lesson, comment on the use of Science equipment if appropriate.

3.6 The frequency of external **interruptions** (if any e.g. intercom; people entering classroom) and how the teacher and learners respond to these.

3.7 How are the learners **organised** in the classroom (rows, groups, pairs)? Be specific about different parts of the lesson especially if the organisation changes during the lesson.

4. INTERPRETATION OF THE TEACHING AND LEARNING IN THIS LESSON

Please give your analysis of what is happening in the classroom (interpretation). This section allows you to use your expertise as a Science or maths specialist to make judgements about what is happening in the classroom.

For this part, it is very important that evidence be presented to justify your claims. Your report should read something like:

The teacher's level of confidence was ….. based on the following evidence ….

4.1 Teacher's level of ***confidence*** in teaching the topic (You should make a judgement about confidence using evidence such as the teachers ability to teach without reference to notes or a textbook; the teacher's confidence in allowing learners to ask questions freely; the teacher's competence in responding to and answering learners questions)

Your report should read something like: **The teacher's level of confidence was ….. based on the following evidence ….**

_____

_____

_____

_____

_____

_____

_____

_____

4.2 Teacher's level of ***subject content knowledge*** in teaching the topic. This requires you to make a judgement about the SCK of the teacher. When making a judgement, you need to provide evidence to support your judgement. Your report should read something like: **This teacher had …… SCK which was evident by his/her use of ……**

_____

_____

_____

_____

_____

_____

4.3 The ***coherence*** of the lesson presented. This requires you to make a judgement on the organisation of the lesson, the use of introduction and conclusion, the lesson as a whole unit of learning. You should comment on whether the learners were able to make sense of the lesson purpose and where it fits into the topic as a whole. **Your report should read something like: This lesson showed poor coherence because ……..**

_____

_____

_____

_____

_____

_____

_____

_____

4.4 The ***cognitive level*** of the lesson presented. This requires you to make a judgement on the cognitive level at which the lesson is pitched. You will need to consider whether the teacher is presenting to work in a way that is too difficult for the learners, or at a level that is too low. You should gather evidence from learner questioning, level of learner engagement in activities.

_____

_____

_____

_____

_____

_____

_____

_____

For any of the points mentioned above:

- Give clear evidence for any judgements
- If there is no evidence to make a claim, indicate that it is not applicable to do so.

5. GENERAL SUMMARY OF TEACHING AND LEARNING

Please use this section to summarise the overall feeling towards this lesson. You should assess in a general sense the kind of teaching and learning you observed in the classroom on the scales below, 1 rating low and 4 rating high.

		1	2	3	4
5.1	This lesson was a traditionally teacher–centred teaching experience				
5.2	This lesson showed evidence of learner–centred learning				
5.2	The learners learned predominantly by rote learning				
5.3	The classroom was generally disorganised and badly managed				
5.4	The was evidence of a negative classroom culture which many have interfered with learning				
5.5	The physical environment constrained the successful implementation of the lesson				
5.6	There was evidence that learning was facilitated through adequate resources				
5.7	There was evidence of active participation by learners in this lesson				
5.8	There was evidence that learning was inhibited by limited resources				

APPENDIX D
CODES FOR THE ANALYSIS OF SCIENCE TEACHER INTERVIEWS

TEACHER INTERVIEW ANALYSIS - LIST OF DEDUCTIVE CODES ADAPTED FROM FET PROJECT (CEA, 2010) FOR THE SECONDARY DATA ANALYSIS

1A: Why did you become a teacher?

1A: Career choice rationale: Altruism
1A: Career choice rationale: Finance
1A: Career choice rationale: Opportunity
1A: Career choice rationale: Compromise
1A: Career choice rationale: Like of children
1A: Career choice rationale: Calling
1A: Career choice rationale: Employment opportunity
1A: Career choice rationale: Job security
1A: Career choice rationale: Perceived job perks

1A: Career feelings: Positive
1A: Career feelings: Negative

1A: Career goals: HoD
1A: Career goals: Principal
1A: Career goals: SMT
1A: Career goals: District
1A: Career goals: DoE
1A: Career goals: Career field change

NEW
1A: Career goals: further studies towards better qualifications

1B: Why specifically Science?

1B: Science subject Rationale: Opportunity
1B: Science subject Rationale: Interest in subject
1B: Science subject Rationale: Passion for subject
1B: Science subject Rationale: School directive

NEW
1B: Science subject rationale: High school subject
1B: Science subject rationale: Tertiary subject/major
1B: Science subject rationale: high marks (SCK) in the subject at secondary school level
1B: Science subject rationale: high marks (SCK) in the subject at tertiary level

1C: What is the most important thing you want your learners to achieve in your Science class?

1C: Main achievement goal: Generalised developmental outcome: Emotional
1C: Main achievement goal: Generalised developmental outcome: Cognitive
1C: Main achievement goal: Generalised developmental outcome: Social
1C: Main achievement goal: Mastery of learning: Topic
1C: Main achievement goal: Mastery of learning: Subject Area
1C: Main achievement goal: Mastery of learning: Overall
1C: Main achievement Goal: Achievement orientation: Marks
1C: Main achievement Goal: Achievement orientation: University exemption
1C: Main achievement Goal: Achievement orientation: High teacher pass rate
1C: Main achievement Goal: Achievement orientation: High school pass rate
1C: Main achievement goal: Love of subject area

2B: How do you deal with teaching Science to your learners? (INDICATION OF PCK)

2B: Learner needs adaptability: Strategies: Revision of Grade 10 work
2B: Learner needs adaptability: Strategies: Revision of Grade 11 work
2B: Learner needs adaptability: Strategies: Extra lessons
2B: Learner needs adaptability: Strategies: Peer tutoring
2B: Learner needs adaptability: Strategies: Encourage change subject area change

2B: Learner needs adaptability: Non-adaptation: Helplessness
2B: Learner needs adaptability: Non-adaptation: Skill deficit

2B: Learner needs awareness: High insight
2B: Learner needs awareness: Low insight
2B: Learner needs awareness: Average insight

4A: Tell me a little bit about the lesson I have just observed.

4A: Lesson type: Practical: Physics
4A: Lesson type: Practical: Chemistry
4A: Lesson type: Theoretical: Physics
4A: Lesson type: Theoretical: Chemistry

NEW
4A: Lesson Content: Revision of Grade 10 work
4A: Lesson Content: Revision of Grade 11 work
4A: Lesson Content: Grade 12 work

4A: SLOS Lesson teaching strategy: whole group activity
4A: SLOS Lesson teaching strategy: small group activity
4A: SLOS Lesson teaching strategy: individual activity

4A: SLOS Learner activities: Listening to input from teacher
4A: SLOS Learner activities: Observing demonstration
4A: SLOS Learner activities: Copying
4A: SLOS Learner activities: Reading
4A: SLOS Learner activities: Writing answers to exercises
4A: SLOS Learner activities: Conducting practical work

4A: SLOS Learner activities: Creative writing or drawing
4A: SLOS Learner activities: Listening to feedback from pupils
4A: SLOS Learner activities: Discussing (active conversation)

4A: SLOS Learner-teacher interactions: Instructions from teacher
4A: SLOS Learner-teacher interactions: Explanation (content) from teacher
4A: SLOS Learner-teacher interactions: Teacher led questioning
4A: SLOS Learner-teacher interactions: Learner led input (feedback)
4A: SLOS Learner-teacher interactions: Learner led questions
4A: SLOS Learner-teacher interactions: Teacher passive

4B: Lesson Planning - tell me about the planning/ preparation that you needed to do for this lesson.

4B: Lesson planning strategy: Grade-based teacher collaboration
4B: Lesson planning strategy: Phase-based teacher collaboration
4B: Lesson planning strategy: HoD led plan
4B: Lesson planning strategy: Personal planning
4B: Lesson planning strategy: multiple planning strategies
4B: Lesson planning strategy: Haphazard planning
4B: Lesson planning strategy: No planning evident

4C: Teaching strategy - I noticed that you used… [group work, learners working in pairs, a presentation, etc.] … to teach this topic. Tell me about why you chose this particular teaching strategy for this lesson.

4C: Lesson teaching strategy: Rationale
4C: Lesson teaching strategy: Adaptation to learner needs
4C: Lesson teaching strategy: Teacher-centred
4C: Lesson teaching strategy: Learner-centred

4E: Sequencing- How does this lesson fit into the whole topic? [Tell me about the lessons before this one and those coming after]

4E: Lesson sequencing rationale: Logical
4E: Lesson sequencing rationale: Haphazard
4E: Lesson sequencing rationale: Not appropriate

4F: Assessment Strategy - Will the content of lesson form part of your assessment? If so, in what way?

4F: Assessment strategy: Formal
4F: Assessment strategy: Informal

NEW
4F: Assessment strategy: Formative

4F: Assessment strategy: Summative
4F: Assessment strategy: Standardised Test
4F: Assessment strategy: Prepared Class Test
4F: Assessment strategy: Prepared Mini Test
4F: Assessment strategy: Impromptu Test
4F: Assessment strategy: Learner marking homework/classwork
4F: Assessment strategy: Teacher marking homework/classwork
4F: Assessment strategy: Teacher marking assignment
4F: Assessment strategy: Quiz

APPENDIX E
CODES FOR THE ANALYSIS OF SCIENCE LESSON OBSERVATIONS

LESSON OBSERVATION ANALYSIS - LIST OF DEDUCTIVE CODES ADAPTED USING FET PROJECT (CEA, 2010); GWIMBI AND MONK (2003); ROGAN AND GRAYSON (2003) FOR THE SECONDARY DATA ANALYSIS

Indication of PCK with regards to learner needs adaptability and strategies used by the Science teacher:

Teacher PCK: Indication of shortfall
Teacher PCK: Indication of high level

2B: Learner needs adaptability: Strategies: Curriculum implementation lag: T: O1 O3 O6 O8
2B: Learner needs adaptability: Strategies: Revision of Senior phase work: T: O1 O3 O6 O8
2B: Learner needs adaptability: Strategies: Extra lessons: T: O1 O3 O6 O8
2B: Learner needs adaptability: Strategies: Peer tutoring: T: O1 O3 O6 O8
2B: Learner needs adaptability: Strategies: Encourage change subject area change: T: O1 O3 O6 O8

2B: Learner needs adaptability: Non-adaptation: Helplessness: T: O1 O3 O6 O8
2B: Learner needs adaptability: Non-adaptation: Skill deficit: T: O1 O3 O6 O8

2B: Learner needs awareness: High insight: T: O3
2B: Learner needs awareness: Low insight: T: O3
2B: Learner needs awareness: Average insight: T: O3

Indication of lesson planning strategy:

4B: Lesson planning strategy: Grade-based teacher collaboration: T: O1 O2 O5 O8
4B: Lesson planning strategy: Phase-based teacher collaboration: T: O1 O2 O5 O8
4B: Lesson planning strategy: HoD led plan: T: O1 O2 O5 O8
4B: Lesson planning strategy: Personal planning: T: O1 O2 O5 O8
4B: Lesson planning strategy: multiple planning strategies: T: O1 O2 O5 O8
4B: Lesson planning strategy: Haphazard planning: T: O1 O2 O5 O8
4B: Lesson planning strategy: No planning evident: T: O1 O2 O5 O8

NEW
4B: Lesson planning strategy: worked from textbook: T: O1 O2 O5 O8
4B: Lesson planning strategy: worked from scheme of work: T: O1 O2 O5 O8

4E. Lesson Sequencing

4E: Lesson sequencing rationale: Logical: T: O5 O8
4E: Lesson sequencing rationale: Haphazard: T: O5 O8

Lesson type:

4A: Lesson type: Practical: Physics: TS: O2 O3 O5 O6 O8
4A: Lesson type: Practical: Chemistry: TS: O2 O3 O5 O6 O8
4A: Lesson type: Theoretical: Physics: TS: O2 O3 O5 O6 O8
4A: Lesson type: Theoretical: Chemistry: TS: O2 O3 O5 O6 O8

Lesson focus:

4C: Lesson focus: Teacher-centred: T: O2 O3
4C: Lesson focus: Learner-centred: T: O2 O3

Teaching strategy used for the observed lesson(s):

4A: SLOS Lesson teaching strategy: whole group activity: T: O2 O3
4A: SLOS Lesson teaching strategy: small group activity: T: O2 O3
4A: SLOS Lesson teaching strategy: individual activity: T: O2 O3

Indication of Teacher SCK:
Teacher SCK: Indication of shortfall
Teacher SCK: Indication of high level
Teacher SCK: Indication of shortfall: Calculation Difficulties
Teacher SCK: Indication of shortfall: Misconceptions

Learner activities:

4A: SLOS Learner activities: Listening to input from teacher: T: O2 O3
4A: SLOS Learner activities: Observing demonstration: T: O2 O3
4A: SLOS Learner activities: Copying: T: O2 O3
4A: SLOS Learner activities: Reading: T: O2 O3
4A: SLOS Learner activities: Writing answers to exercises: T: O2 O3
4A: SLOS Learner activities: Conducting practical work: T: O2 O3
4A: SLOS Learner activities: Creative writing or drawing: T: O2 O3
4A: SLOS Learner activities: Listening to feedback from pupils: T: O2 O3
4A: SLOS Learner activities: Discussing (active conversation): T: O2 O3

R&G: L2: Classroom interaction: Learner activities: Learners use additional (to text book) sources of information in compiling notes
R&G: L2: Classroom interaction: Learner activities: Learners make own notes on the concepts learned from doing these activities
R&G: L3: Classroom interaction: Learner involvement: Learners engage in minds-on learning activities
R&G: L3: Classroom interaction: Learner involvement: Learners make own notes on the concepts learned from doing minds-on learning activities
R&G: L4: Classroom interaction: Learner involvement: Learners take major responsibility for their own learning; partake in the planning and assessment of their own learning
R&G: L4: Classroom interaction: Learner involvement: Learners undertake long term and community-based investigations projects

Learner-teacher interactions:

4A: SLOS Learner-teacher interactions: Instructions from teacher: T: O2 O3
4A: SLOS Learner-teacher interactions: Explanation (content) from teacher: T: O2 O3
4A: SLOS Learner-teacher interactions: Teacher led questioning: T: O2 O3
4A: SLOS Learner-teacher interactions: Learner led input (feedback): T: O2 O3
4A: SLOS Learner-teacher interactions: Learner led questions: T: O2 O3
4A: SLOS Learner-teacher interactions: Teacher passive: T: O2 O3
4A: SLOS Learner-teacher interactions: Other: T: O2 O3

R&G: L1: Classroom interaction: Learner behaviour: attentive and engaged
R&G: L1: Classroom interaction: Learner involvement: Learners respond to and initiate questions
R&G: L2: Classroom interaction: Learner involvement: Learners engage in meaningful group work
R&G: L1: Science in Society: Learner activities: Learners ask questions about Science in the context of everyday life

R&G: L1: Classroom interaction: Teacher: Content presentation: well organized
R&G: L1: Classroom interaction: Teacher: Content presentation: correct and well sequenced manner
R&G: L1: Classroom interaction: Teacher: Content presentation: based on a well-designed lesson plan
R&G: L1: Classroom interaction: Teacher: Resource use: provides adequate notes
R&G: L1: Classroom interaction: Teacher: Resource use: uses textbook effectively
R&G: L2: Classroom interaction: Teacher: Resource use: uses textbooks along with other resources
R&G: L1: Classroom interaction: Teacher Involvement: engages learners with questions
R&G: L2: Classroom interaction: Teacher Involvement: engages learners with questions that encourage in-depth thinking
R&G: L3: Classroom interaction: Teacher Involvement: Teacher probes learners' prior knowledge.
R&G: L3: Classroom interaction: Teacher Involvement: Teacher structures learning activities along 'good practice' lines (knowledge is constructed, is relevant, and is based on problem solving techniques)
R&G: L3: Classroom interaction: Teacher Involvement: Teacher introduces learners to the evolving nature of scientific knowledge
R&G: L4: Classroom interaction: Teacher Involvement: Teacher facilitates learners as they design and undertake long-term investigations and projects
R&G: L4: Classroom interaction: Teacher Involvement: Teacher assists learners to weigh up the merits of different theories/methods that attempt to explain the same phenomena

Practical Work:
R&G: L1: Practical work: classroom demonstrations
R&G: L2: Practical work: demonstrations to promote a limited form of inquiry
R&G: L1: Practical work: uses specimens found in the local environment to illustrate lessons
R&G: L3: Practical work: designed to encourage learner discovery of information

R&G: L2: Practical work: Learners assist in planning and performing the demonstrations
R&G: L2: Practical work: Learners participate in closed (cook-book) practical work
R&G: L2: Practical work: Learners communicate data using graphs and tables
R&G: L3: Practical work: Learners perform 'guided discovery' type practical work in small groups, engaging in hands-on activities
R&G: L3: Practical work: Learners write a scientific report and justify their conclusions in terms of the data collected
R&G: L4: Practical work: Learners design and do their own 'open' investigations
R&G: L4: Practical work: Learners reflect on the quality of the design and collected data, and make improvements
R&G: L4: Practical work: Learners interpret data in support of theories or explanations

Science in Society:

R&G: L1: Science in Society: Teacher uses examples and applications from everyday life to illustrate scientific concepts
R&G: L2: Science in Society: Teacher bases a lesson(s) on a specific problem or issue faced by the local community
R&G: L2: Science in Society: Teacher assists learners to explore the explanations of scientific phenomena by different cultural groups
R&G: L3: Science in Society: Learners actively investigate the application of Science and technology in their own environment, mainly by means of data gathering methods such as surveys
R&G: L4: Science in Society: Learners actively undertake a project in their local community in which they apply Science to tackle a specific problem or to meet a specific need
R&G: L4: Science in Society: Learners explore the long term effects of community projects

4F. Assessment Strategies used in the observed lesson:
4F: Assessment strategy: Formal: T: O6 08
4F: Assessment strategy: Informal: T: O6 08
NEW
4F: Assessment strategy: Formative: T: O6 08
4F: Assessment strategy: Summative: T: O6 08
4F: Assessment strategy: Standardised Test: T: O6 08
4F: Assessment strategy: Prepared Class Test: T: O6 08
4F: Assessment strategy: Prepared Mini Test: T: O6 08
4F: Assessment strategy: Impromptu Test: T: O6 08
4F: Assessment strategy: Learner marking homework/classwork: T: O6 08
4F: Assessment strategy: Teacher marking homework/classwork: T: O6 08
4F: Assessment strategy: Teacher marking assignment: T: O6 08
4F: Assessment strategy: Quiz: T: O6 08

APPENDIX F
DATA ANALYSIS – QUANTITATIVE

DESCRIPTIVE STATISTICS

Descriptive Statistics						
	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Overall pass rate	19	5,00	72,00	26,6316	4,44276	19,36552
Highest level of formal education	19	5,00	8,00	5,6316	,19058	,83070
Teaching diploma/certificate	19	0,00	1,00	,9474	,05263	,22942
categories of teaching qualifications	16	1,00	5,00	4,1250	,23936	,95743
Type of diploma/certificate	15	3,00	9,00	5,8667	,62386	2,41622
Teaching experience altogether	19	7,00	40,00	15,1579	1,79874	7,84052
Physical Science teaching experience	19	5,00	40,00	15,0000	1,85277	8,07603
Years teaching FET phase	19	1,00	23,00	9,6316	1,42289	6,20224
Teaching the class as a whole	19	30,00	98,00	55,3158	4,25987	18,56835
Working with individual learners	19	0,00	60,00	10,6316	2,92520	12,75064
Working with small groups	19	0,00	60,00	11,2632	3,05681	13,32434
Engaging learners in problem solving activities	19	5,00	100,00	27,0000	6,81373	29,70036
Administrative duties	19	0,00	70,00	11,0000	3,44972	15,03699
Maintaining discipline	19	1,00	100,00	17,8421	6,86003	29,90218
A copy of the NCS	19	1,00	1,00	1,0000	0,00000	0,00000
An annual work schedule	19	1,00	1,00	1,0000	0,00000	0,00000
A term plan	18	0,00	1,00	,8333	,09039	,38348
A weekly plan	18	0,00	1,00	,6667	,11433	,48507
A lesson plan	19	1,00	1,00	1,0000	0,00000	0,00000
A timetable	19	1,00	1,00	1,0000	0,00000	0,00000
A classlist for each class taught	18	0,00	1,00	,8889	,07622	,32338
A mark schedule/progress chart	19	0,00	1,00	,9474	,05263	,22942
Teaching Physical Science as a whole-class activity	19	2,00	4,00	3,5263	,14035	,61178

Teaching Physical Science with same ability groups	19	1,00	4,00	2,0526	,22261	,97032
Teaching Physical Science with mixed-ability groups	19	1,00	4,00	2,4211	,20684	,90159
Teaching Physical Science using individualised instruction for teaching	19	1,00	4,00	2,3684	,20535	,89508
Learners work independently on an assigned plan or goal	19	2,00	4,00	2,6316	,17456	,76089
Learners work independently on a goal they choose themselves	19	1,00	4,00	2,2632	,16827	,73349
Motion in 2 dimension	18	1,00	3,00	2,3889	,14323	,60768
Work power and energy	18	2,00	3,00	2,6667	,11433	,48507
Doppler effect	18	2,00	3,00	2,6111	,11824	,50163
Colour	18	1,00	3,00	2,6667	,14003	,59409
Diffraction and interference	18	2,00	3,00	2,6667	,11433	,48507
Wave nature of matter	18	1,00	3,00	2,3889	,14323	,60768
Electrodynamics	18	1,00	3,00	2,5000	,14575	,61835
Electronics: Circuits	18	1,00	3,00	2,0556	,17097	,72536
Electromagnetic radiation	17	1,00	3,00	2,2941	,16638	,68599
Optical properties of matter	18	1,00	3,00	2,1667	,12127	,51450
Organic molecules	18	1,00	3,00	2,7222	,13541	,57451
Mechanical properties of matter	18	1,00	3,00	2,3889	,16447	,69780
Organic macromolecules	18	1,00	3,00	2,5556	,14512	,61570
Rate and extent of reactions	18	2,00	3,00	2,7222	,10863	,46089
Electrochemical reactions	18	2,00	3,00	2,7778	,10083	,42779
Chemical industry	18	1,00	3,00	2,2778	,17723	,75190
Record various types of assessment	19	2,00	4,00	3,6842	,13361	,58239
Requirements of assessment impacts negatively on time available for teaching and learning	19	1,00	4,00	3,3158	,20308	,88523
Make use of feedback on assessment to support individual learners	19	2,00	4,00	3,6842	,13361	,58239

Results of the external examination is a true reflection of learners' attainment of learning outcomes	19	1,00	4,00	2,6316	,19058	,83070
Assessment provides useful evidence of learners' understanding used to plan subsequent lessons	19	3,00	4,00	3,7895	,09609	,41885
Identify learners' strengths and advise them how to develop them further	19	3,00	4,00	3,7895	,09609	,41885
Next lesson is determined more by prescribed curriculum than by how well learners did in the last lesson	19	1,00	4,00	3,2632	,21415	,93346
Curriculum	18	3,00	5,00	4,3889	,18327	,77754
Textbook	18	3,00	5,00	4,1667	,18524	,78591
Learners' progress through assessment	19	2,00	5,00	4,1579	,19138	,83421
Informal classroom assessment	18	2,00	5,00	4,1667	,20211	,85749
Consulting with colleagues	19	2,00	5,00	4,2105	,19615	,85498
Cluster meetings	19	1,00	5,00	3,7368	,32302	1,40800
Teacher workshops	19	1,00	5,00	3,8421	,27850	1,21395
Group work	19	2,00	5,00	3,7895	,24873	1,08418
Cooperative learning	18	2,00	5,00	3,9444	,20567	,87260
Direct instruction	18	2,00	5,00	4,0556	,18912	,80237
Project work	19	2,00	5,00	4,1053	,21487	,93659
Individual work	19	2,00	5,00	3,8947	,28505	1,24252
Drill and practice	19	1,00	5,00	3,7895	,30184	1,31567
Problem solving	18	2,00	5,00	4,6111	,20031	,84984
Hands on activities	18	2,00	5,00	4,5000	,20211	,85749
Teacher demonstration	18	2,00	5,00	4,1667	,23221	,98518
Valid N (listwise)	11					

FREQUENCY TABLES

Overall pass rate

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5.00	2	10,5	10,5	10,5
	8.00	2	10,5	10,5	21,1
	9.00	1	5,3	5,3	26,3
	14.00	2	10,5	10,5	36,8
	20.00	2	10,5	10,5	47,4
	22.00	1	5,3	5,3	52,6
	25.00	1	5,3	5,3	57,9
	28.00	1	5,3	5,3	63,2
	32.00	2	10,5	10,5	73,7
	37.00	1	5,3	5,3	78,9
	39.00	1	5,3	t	84,2
	54.00	1	5,3	5,3	89,5
	62.00	1	5,3	5,3	94,7
	72.00	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Highest level of formal education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Finished degree or diploma	10	52,6	52,6	52,6
	Finished post graduate degree	7	36,8	36,8	89,5
	Finished postgraduate degree - Masters	1	5,3	5,3	94,7
	finished postgraduate degree - PhD	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Teaching diploma/certificate

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	1	5,3	5,3	5,3
	Yes	18	94,7	94,7	100,0
	Total	19	100,0	100,0	

Categories of Teaching Qualifications

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	non-qualified	1	5,3	6,3	6,3
	Teaching Diploma	10	52,6	62,5	68,8
	Postgraduate Degree or Certificate in Education	5	26,3	31,3	100,0
	Total	16	84,2	100,0	
Missing	System	3	15,8		
Total		19	100,0		

Type of diploma/certificate

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secondary Education Diploma	4	21,1	26,7	26,7
	3-year College of Education Diploma	2	10,5	13,3	40,0
	4-year College of Education Diploma	1	5,3	6,7	46,7
	ACE	1	5,3	6,7	53,3
	Further diploma of Education	2	10,5	13,3	66,7
	HED	2	10,5	13,3	80,0
	PGCE	3	15,8	20,0	100,0
	Total	15	78,9	100,0	
Missing	System	4	21,1		
Total		19	100,0		

Teaching experience altogether

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	7.00	3	15,8	15,8	15,8
	10.00	2	10,5	10,5	26,3
	11.00	2	10,5	10,5	36,8
	12.00	3	15,8	15,8	52,6
	15.00	1	5,3	5,3	57,9
	16.00	1	5,3	5,3	63,2
	17.00	1	5,3	5,3	68,4
	18.00	3	15,8	15,8	84,2
	22.00	1	5,3	5,3	89,5
	25.00	1	5,3	5,3	94,7
	40.00	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Physical Science teaching experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5.00	1	5,3	5,3	5,3
	7.00	2	10,5	10,5	15,8
	10.00	3	15,8	15,8	31,6
	11.00	2	10,5	10,5	42,1
	12.00	2	10,5	10,5	52,6
	15.00	1	5,3	5,3	57,9
	16.00	1	5,3	5,3	63,2
	17.00	1	5,3	5,3	68,4
	18.00	3	15,8	15,8	84,2
	23.00	1	5,3	5,3	89,5
	25.00	1	5,3	5,3	94,7
	40.00	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Years teaching FET phase

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	1	5,3	5,3	5,3
	3.00	4	21,1	21,1	26,3
	5.00	1	5,3	5,3	31,6
	7.00	2	10,5	10,5	42,1
	9.00	2	10,5	10,5	52,6
	10.00	2	10,5	10,5	63,2
	11.00	2	10,5	10,5	73,7
	15.00	1	5,3	5,3	78,9
	17.00	1	5,3	5,3	84,2
	18.00	2	10,5	10,5	94,7
	23.00	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Teaching the class as a whole

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30.00	3	15,8	15,8	15,8
	33.00	1	5,3	5,3	21,1
	40.00	1	5,3	5,3	26,3
	50.00	3	15,8	15,8	42,1
	55.00	3	15,8	15,8	57,9
	60.00	3	15,8	15,8	73,7
	65.00	1	5,3	5,3	78,9
	70.00	1	5,3	5,3	84,2
	75.00	1	5,3	5,3	89,5
	85.00	1	5,3	5,3	94,7
	98.00	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Working with individual learners

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1	5,3	5,3	5,3
	5.00	8	42,1	42,1	47,4
	7.00	1	5,3	5,3	52,6
	10.00	6	31,6	31,6	84,2
	15.00	1	5,3	5,3	89,5
	20.00	1	5,3	5,3	94,7
	60.00	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Working with small groups

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1	5,3	5,3	5,3
	5.00	8	42,1	42,1	47,4
	9.00	1	5,3	5,3	52,6
	10.00	6	31,6	31,6	84,2
	15.00	1	5,3	5,3	89,5
	30.00	1	5,3	5,3	94,7
	60.00	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Engaging learners in problem solving activities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5.00	3	15,8	15,8	15,8
	10.00	7	36,8	36,8	52,6
	15.00	1	5,3	5,3	57,9
	20.00	2	10,5	10,5	68,4
	25.00	1	5,3	5,3	73,7
	40.00	1	5,3	5,3	78,9
	50.00	1	5,3	5,3	84,2
	60.00	1	5,3	5,3	89,5
	98.00	1	5,3	5,3	94,7
	100.00	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Administrative duties

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1	5,3	5,3	5,3
	2.00	1	5,3	5,3	10,5
	3.00	1	5,3	5,3	15,8
	5.00	6	31,6	31,6	47,4
	9.00	1	5,3	5,3	52,6
	10.00	6	31,6	31,6	84,2
	15.00	1	5,3	5,3	89,5
	20.00	1	5,3	5,3	94,7
	70.00	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Maintaining discipline

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	1	5,3	5,3	5,3
	2.00	1	5,3	5,3	10,5
	3.00	1	5,3	5,3	15,8
	5.00	9	47,4	47,4	63,2
	10.00	3	15,8	15,8	78,9
	20.00	1	5,3	5,3	84,2
	40.00	1	5,3	5,3	89,5
	98.00	1	5,3	5,3	94,7
	100.00	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

A copy of the NCS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	19	100,0	100,0	100,0

An annual work schedule

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	19	100,0	100,0	100,0

A term plan

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	3	15,8	16,7	16,7
	Yes	15	78,9	83,3	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

A weekly plan

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	6	31,6	33,3	33,3
	Yes	12	63,2	66,7	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

A lesson plan

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	19	100,0	100,0	100,0

A timetable

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	19	100,0	100,0	100,0

A classlist for each class taught

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	2	10,5	11,1	11,1
	Yes	16	84,2	88,9	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

A mark schedule/progress chart

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	1	5,3	5,3	5,3
	Yes	18	94,7	94,7	100,0
	Total	19	100,0	100,0	

Teaching Physical Science as a whole-class activity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Sometimes	1	5,3	5,3	5,3
	Often	7	36,8	36,8	42,1
	Always or almost always	11	57,9	57,9	100,0
	Total	19	100,0	100,0	

Teaching Physical Science with same ability groups

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	6	31,6	31,6	31,6
	Sometimes	8	42,1	42,1	73,7
	Often	3	15,8	15,8	89,5
	Always or almost always	2	10,5	10,5	100,0
	Total	19	100,0	100,0	

Teaching Physical Science with mixed-ability groups

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	2	10,5	10,5	10,5
	Sometimes	10	52,6	52,6	63,2
	Often	4	21,1	21,1	84,2
	Always or almost always	3	15,8	15,8	100,0
	Total	19	100,0	100,0	

Teaching Physical Science using individualised instruction for teaching

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	3	15,8	15,8	15,8
	Sometimes	8	42,1	42,1	57,9
	Often	6	31,6	31,6	89,5
	Always or almost always	2	10,5	10,5	100,0
	Total	19	100,0	100,0	

Learners work independently on an assigned plan or goal

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Sometimes	10	52,6	52,6	52,6
	Often	6	31,6	31,6	84,2
	Always or almost always	3	15,8	15,8	100,0
	Total	19	100,0	100,0	

Learners work independently on a goal they choose themselves

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	2	10,5	10,5	10,5
	Sometimes	11	57,9	57,9	68,4
	Often	5	26,3	26,3	94,7
	Always or almost always	1	5,3	5,3	100,0
	Total	19	100,0	100,0	

Motion in 2 dimension

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	1	5,3	5,6	5,6
	Ready	9	47,4	50,0	55,6
	Very ready	8	42,1	44,4	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Work power and energy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ready	6	31,6	33,3	33,3
	Very ready	12	63,2	66,7	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Doppler effect

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ready	7	36,8	38,9	38,9
	Very ready	11	57,9	61,1	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Colour

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	1	5,3	5,6	5,6
	Ready	4	21,1	22,2	27,8
	Very ready	13	68,4	72,2	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Diffraction and interference

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ready	6	31,6	33,3	33,3
	Very ready	12	63,2	66,7	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Wave nature of matter

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	1	5,3	5,6	5,6
	Ready	9	47,4	50,0	55,6
	Very ready	8	42,1	44,4	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Electrodynamics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	1	5,3	5,6	5,6
	Ready	7	36,8	38,9	44,4
	Very ready	10	52,6	55,6	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Electronics: Circuits

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	4	21,1	22,2	22,2
	Ready	9	47,4	50,0	72,2
	Very ready	5	26,3	27,8	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Electromagnetic radiation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	2	10,5	11,8	11,8
	Ready	8	42,1	47,1	58,8
	Very ready	7	36,8	41,2	100,0
	Total	17	89,5	100,0	
Missing	System	2	10,5		
Total		19	100,0		

Optical properties of matter

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	1	5,3	5,6	5,6
	Ready	13	68,4	72,2	77,8
	Very ready	4	21,1	22,2	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Organic molecules

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	1	5,3	5,6	5,6
	Ready	3	15,8	16,7	22,2
	Very ready	14	73,7	77,8	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Mechanical properties of matter

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	2	10,5	11,1	11,1
	Ready	7	36,8	38,9	50,0
	Very ready	9	47,4	50,0	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Organic macromolecules

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	1	5,3	5,6	5,6
	Ready	6	31,6	33,3	38,9
	Very ready	11	57,9	61,1	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Rate and extent of reactions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ready	5	26,3	27,8	27,8
	Very ready	13	68,4	72,2	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Electrochemical reactions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ready	4	21,1	22,2	22,2
	Very ready	14	73,7	77,8	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Chemical industry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not ready	3	15,8	16,7	16,7
	Ready	7	36,8	38,9	55,6
	Very ready	8	42,1	44,4	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Record various types of assessment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree a little	1	5,3	5,3	5,3
	Agree a little	4	21,1	21,1	26,3
	Agree a lot	14	73,7	73,7	100,0
	Total	19	100,0	100,0	

Requirements of assessment impacts negatively on time available for teaching and learning

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree a lot	1	5,3	5,3	5,3
	Disagree a little	2	10,5	10,5	15,8
	Agree a little	6	31,6	31,6	47,4
	Agree a lot	10	52,6	52,6	100,0
	Total	19	100,0	100,0	

Make use of feedback on assessment to support individual learners

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree a little	1	5,3	5,3	5,3
	Agree a little	4	21,1	21,1	26,3
	Agree a lot	14	73,7	73,7	100,0
	Total	19	100,0	100,0	

Results of the external examination is a true reflection of learners' attainment of learning outcomes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree a lot	2	10,5	10,5	10,5
	Disagree a little	5	26,3	26,3	36,8
	Agree a little	10	52,6	52,6	89,5
	Agree a lot	2	10,5	10,5	100,0
	Total	19	100,0	100,0	

Assessment provides useful evidence of learners' understanding used to plan subsequent lessons

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree a little	4	21,1	21,1	21,1
	Agree a lot	15	78,9	78,9	100,0
	Total	19	100,0	100,0	

Identify learners' strengths and advise them how to develop them further

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree a little	4	21,1	21,1	21,1
	Agree a lot	15	78,9	78,9	100,0
	Total	19	100,0	100,0	

Next lesson is determined more by prescribed curriculum than by how well learners did in the last lesson

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree a lot	1	5,3	5,3	5,3
	Disagree a little	3	15,8	15,8	21,1
	Agree a little	5	26,3	26,3	47,4
	Agree a lot	10	52,6	52,6	100,0
	Total	19	100,0	100,0	

Curriculum

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	3	15,8	16,7	16,7
	Rather high	5	26,3	27,8	44,4
	High	10	52,6	55,6	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Textbook

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	4	21,1	22,2	22,2
	Rather high	7	36,8	38,9	61,1
	High	7	36,8	38,9	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Learners' progress through assessment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	1	5,3	5,3	5,3
	Neutral	2	10,5	10,5	15,8
	Rather high	9	47,4	47,4	63,2
	High	7	36,8	36,8	100,0
	Total	19	100,0	100,0	

Informal classroom assessment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	1	5,3	5,6	5,6
	Neutral	2	10,5	11,1	16,7
	Rather high	8	42,1	44,4	61,1
	High	7	36,8	38,9	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Consulting with colleagues

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	1	5,3	5,3	5,3
	Neutral	2	10,5	10,5	15,8
	Rather high	8	42,1	42,1	57,9
	High	8	42,1	42,1	100,0
	Total	19	100,0	100,0	

Cluster meetings

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	2	10,5	10,5	10,5
	Rather low	2	10,5	10,5	21,1
	Neutral	3	15,8	15,8	36,8
	Rather high	4	21,1	21,1	57,9
	High	8	42,1	42,1	100,0
	Total	19	100,0	100,0	

Teacher workshops

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	1	5,3	5,3	5,3
	Rather low	2	10,5	10,5	15,8
	Neutral	3	15,8	15,8	31,6
	Rather high	6	31,6	31,6	63,2
	High	7	36,8	36,8	100,0
	Total	19	100,0	100,0	

Group work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	3	15,8	15,8	15,8
	Neutral	4	21,1	21,1	36,8
	Rather high	6	31,6	31,6	68,4
	High	6	31,6	31,6	100,0
	Total	19	100,0	100,0	

Cooperative learning

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	1	5,3	5,6	5,6
	Neutral	4	21,1	22,2	27,8
	Rather high	8	42,1	44,4	72,2
	High	5	26,3	27,8	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Direct instruction

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	1	5,3	5,6	5,6
	Neutral	2	10,5	11,1	16,7
	Rather high	10	52,6	55,6	72,2
	High	5	26,3	27,8	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Project work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	2	10,5	10,5	10,5
	Neutral	1	5,3	5,3	15,8
	Rather high	9	47,4	47,4	63,2
	High	7	36,8	36,8	100,0
	Total	19	100,0	100,0	

Individual work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	4	21,1	21,1	21,1
	Neutral	3	15,8	15,8	36,8
	Rather high	3	15,8	15,8	52,6
	High	9	47,4	47,4	100,0
	Total	19	100,0	100,0	

Drill and practice

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	1	5,3	5,3	5,3
	Rather low	3	15,8	15,8	21,1
	Neutral	3	15,8	15,8	36,8
	Rather high	4	21,1	21,1	57,9
	High	8	42,1	42,1	100,0
	Total	19	100,0	100,0	

Problem solving

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	1	5,3	5,6	5,6
	Neutral	1	5,3	5,6	11,1
	Rather high	2	10,5	11,1	22,2
	High	14	73,7	77,8	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Hands on activities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	1	5,3	5,6	5,6
	Neutral	1	5,3	5,6	11,1
	Rather high	4	21,1	22,2	33,3
	High	12	63,2	66,7	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

Teacher demonstration

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rather low	2	10,5	11,1	11,1
	Neutral	1	5,3	5,6	16,7
	Rather high	7	36,8	38,9	55,6
	High	8	42,1	44,4	100,0
	Total	18	94,7	100,0	
Missing	System	1	5,3		
Total		19	100,0		

CORRELATIONS

		Overall pass rate
Overall pass rate	Pearson Correlation	1
	Sig. (2-tailed)	
	N	19
Highest level of formal education	Pearson Correlation	,057
	Sig. (2-tailed)	,818
	N	19
Teaching diploma/certificate	Pearson Correlation	,158
	Sig. (2-tailed)	,518
	N	19
categories of teaching qualifications	Pearson Correlation	,381
	Sig. (2-tailed)	,145
	N	16
Type of diploma/certificate	Pearson Correlation	,416
	Sig. (2-tailed)	,123
	N	15
Teaching experience altogether	Pearson Correlation	.495*
	Sig. (2-tailed)	,031
	N	19
Physical Science teaching experience	Pearson Correlation	.477*
	Sig. (2-tailed)	,039
	N	19
Years teaching FET phase	Pearson Correlation	-,001
	Sig. (2-tailed)	,998
	N	19
Teaching the class as a whole	Pearson Correlation	-,066
	Sig. (2-tailed)	,788
	N	19
Working with individual learners	Pearson Correlation	-,184
	Sig. (2-tailed)	,452
	N	19
Working with small groups	Pearson Correlation	-,014
	Sig. (2-tailed)	,955
	N	19
Engaging learners in problem solving activities	Pearson Correlation	-,138
	Sig. (2-tailed)	,572
	N	19
Administrative duties	Pearson Correlation	-,214
	Sig. (2-tailed)	,379
	N	19

Maintaining discipline	Pearson Correlation	-,056
	Sig. (2-tailed)	,820
	N	19
A copy of the NCS	Pearson Correlation	.[b]
	Sig. (2-tailed)	
	N	19
An annual work schedule	Pearson Correlation	.[b]
	Sig. (2-tailed)	
	N	19
A term plan	Pearson Correlation	,159
	Sig. (2-tailed)	,528
	N	18
A weekly plan	Pearson Correlation	,188
	Sig. (2-tailed)	,456
	N	18
A lesson plan	Pearson Correlation	.[b]
	Sig. (2-tailed)	
	N	19
A timetable	Pearson Correlation	.[b]
	Sig. (2-tailed)	
	N	19
A classlist for each class taught	Pearson Correlation	-,245
	Sig. (2-tailed)	,326
	N	18
A mark schedule/progress chart	Pearson Correlation	,233
	Sig. (2-tailed)	,337
	N	19
Teaching Physical Science as a whole-class activity	Pearson Correlation	-,053
	Sig. (2-tailed)	,829
	N	19
Teaching Physical Science with same ability groups	Pearson Correlation	,202
	Sig. (2-tailed)	,407
	N	19
Teaching Physical Science with mixed-ability groups	Pearson Correlation	,028
	Sig. (2-tailed)	,908
	N	19
Teaching Physical Science using individualised instruction for teaching	Pearson Correlation	-,110
	Sig. (2-tailed)	,653
	N	19
Learners work independently on an assigned plan or goal	Pearson Correlation	-,078
	Sig. (2-tailed)	,752
	N	19

Learners work independently on a goal they choose themselves	Pearson Correlation	-,204
	Sig. (2-tailed)	,402
	N	19
Motion in 2 dimension	Pearson Correlation	-,396
	Sig. (2-tailed)	,104
	N	18
Work power and energy	Pearson Correlation	,189
	Sig. (2-tailed)	,452
	N	18
Doppler effect	Pearson Correlation	,085
	Sig. (2-tailed)	,739
	N	18
Colour	Pearson Correlation	-,149
	Sig. (2-tailed)	,554
	N	18
Diffraction and interference	Pearson Correlation	-,427
	Sig. (2-tailed)	,077
	N	18
Wave nature of matter	Pearson Correlation	-,226
	Sig. (2-tailed)	,368
	N	18
Electrodynamics	Pearson Correlation	,005
	Sig. (2-tailed)	,985
	N	18
Electronics: Circuits	Pearson Correlation	-,189
	Sig. (2-tailed)	,453
	N	18
Electromagnetic radiation	Pearson Correlation	-,315
	Sig. (2-tailed)	,217
	N	17
Optical properties of matter	Pearson Correlation	-,115
	Sig. (2-tailed)	,650
	N	18
Organic molecules	Pearson Correlation	-,058
	Sig. (2-tailed)	,818
	N	18
Mechanical properties of matter	Pearson Correlation	-,366
	Sig. (2-tailed)	,135
	N	18
Organic macromolecules	Pearson Correlation	-,011
	Sig. (2-tailed)	,965
	N	18

Rate and extent of reactions	Pearson Correlation	-,079
	Sig. (2-tailed)	,755
	N	18
Electrochemical reactions	Pearson Correlation	,161
	Sig. (2-tailed)	,522
	N	18
Chemical industry	Pearson Correlation	,222
	Sig. (2-tailed)	,377
	N	18
Record various types of assessment	Pearson Correlation	-,139
	Sig. (2-tailed)	,570
	N	19
Requirements of assessment impacts negatively on time available for teaching and learning	Pearson Correlation	-,006
	Sig. (2-tailed)	,981
	N	19
Make use of feedback on assessment to support individual learners	Pearson Correlation	-,346
	Sig. (2-tailed)	,147
	N	19
Results of the external examination is a true reflection of learners' attainment of learning outcomes	Pearson Correlation	-,106
	Sig. (2-tailed)	,667
	N	19
Assessment provides useful evidence of learners' understanding used to plan subsequent lessons	Pearson Correlation	,127
	Sig. (2-tailed)	,605
	N	19
Identify learners' strengths and advise them how to develop them further	Pearson Correlation	-.599**
	Sig. (2-tailed)	,007
	N	19
Next lesson is determined more by prescribed curriculum than by how well learners did in the last lesson	Pearson Correlation	-,062
	Sig. (2-tailed)	,801
	N	19
Curriculum	Pearson Correlation	-,096
	Sig. (2-tailed)	,704
	N	18
Textbook	Pearson Correlation	-,230
	Sig. (2-tailed)	,359
	N	18
Learners' progress through assessment	Pearson Correlation	-,216
	Sig. (2-tailed)	,374
	N	19

Informal classroom assessment	Pearson Correlation	-,104
	Sig. (2-tailed)	,683
	N	18
Consulting with colleagues	Pearson Correlation	-,109
	Sig. (2-tailed)	,656
	N	19
Cluster meetings	Pearson Correlation	-,036
	Sig. (2-tailed)	,883
	N	19
Teacher workshops	Pearson Correlation	-,142
	Sig. (2-tailed)	,562
	N	19
Group work	Pearson Correlation	-,062
	Sig. (2-tailed)	,801
	N	19
Cooperative learning	Pearson Correlation	-,133
	Sig. (2-tailed)	,598
	N	18
Direct instruction	Pearson Correlation	-,256
	Sig. (2-tailed)	,306
	N	18
Project work	Pearson Correlation	-,307
	Sig. (2-tailed)	,201
	N	19
Individual work	Pearson Correlation	-,154
	Sig. (2-tailed)	,529
	N	19
Drill and practice	Pearson Correlation	,034
	Sig. (2-tailed)	,891
	N	19
Problem solving	Pearson Correlation	-,096
	Sig. (2-tailed)	,704
	N	18
Hands on activities	Pearson Correlation	-,052
	Sig. (2-tailed)	,838
	N	18
Teacher demonstration	Pearson Correlation	,030
	Sig. (2-tailed)	,906
	N	18

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
b. Cannot be computed because at least one of the variables is constant.

APPENDIX G
LEARNER ACHIEVEMENT RESULTS IN TERMS OF PASS RATES

School Codes	Science Teacher Codes	Highest Level of Formal Education	Teaching Diploma/ Certificate	Type of Diploma/ Certificate	Teaching Experience altogether (Total years)	Physical Science Teaching Experience (Years)	Pass Rate (>30%) for NCS Physical Science Examinations (%)
1	TS1	Finished post graduate degree	Yes	3-year College of Education Diploma	18	18	54
2	TS1	Finished degree or diploma	No	N/A	18	18	14
4	TS2	Finished degree or diploma	Yes	HED	40	40	72
5	TS2	Finished degree or diploma	Yes	Other	17	8	13
6	TS1	Finished post graduate degree	Yes	Secondary Education Diploma	18	18	32
6	TS2	Finished post graduate degree	Yes	PGCE	16	16	32
8	TS2	Finished degree or diploma	Yes	3-year College of Education Diploma	7	5	37
9	TS1	Finished post graduate degree	Yes	HED	7	7	25
12	TS1	Omitted	Yes	Omitted	12	12	20
12	TS2	Finished post graduate degree	Yes	PGCE	12	10	20
13	TS1	Finished degree or diploma	Yes	PGCE	17	17	62
14	TS4	Finished post graduate degree	Yes	Secondary Education Diploma	25	25	9

School Codes	Science Teacher Codes	Highest Level of Formal Education	Teaching Diploma/ Certificate	Type of Diploma/ Certificate	Teaching Experience altogether (Total years)	Physical Science Teaching Experience (Years)	Pass Rate (>30%) for NCS Physical Science Examinations (%)
15	TS2	Finished degree or diploma	Yes	Further Diploma of Education	11	11	39
16	TS1	Finished degree or diploma	Yes	College of Education Diploma	10	10	14
17	TS1	Finished post graduate degree	Yes	Further Diploma of Education	15	15	8
17	TS2	Finished post graduate degree	Yes	Other	12	12	8
18	TS1	Finished degree or diploma	Yes	Secondary Education Diploma	7	7	5