LEARNER EXPERIENCES OF TRANSITION FROM THE GENERAL EDUCATION AND TRAINING BAND TO THE FURTHER EDUCATION AND TRAINING BAND IN SCIENCE

by

Makunye Joseph Peloagae

Submitted in partial fulfilment of the requirements for the degree

PhD

in the

Faculty of Education

at the

University of Pretoria

Supervisor: **Dr Estelle Gaigher**

December 2009

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the degree of *Philosophae Doctor* at the University of Pretoria, Pretoria. It has not been submitted before for any degree or examination at any other University.

____

M.J. PELOAGAE

11 December 2009

DEDICATION

Dedicated to my late father, Mosedi, my late mother Mmaseithuti, my wife Beatrice, my three children Onkgopotse Mosedi, Mmapelo Mmaseithuti and Katlego as well as my sisters and brothers.

ACKNOWLEDGEMENTS

My sincere gratitude goes to my supervisor Dr Estelle Gaigher for her patience and dedication in guiding me through the process of compiling this thesis. Her constructive criticism of my drafts helped me to gradually develop as a philosopher of science education and to understand and realize the challenges facing researchers in science education. I would also like to extend my sincere gratitude to Dr L. Jita for his unselfish support and good advice during the initial stages of my studies.

As my study also used quantitative data, I had to rely on assistance from statisticians. I would therefore also extend my gratitude to Dr Mike Van der Linde and Dr Liebie Louw for their tireless efforts in assisting me with the descriptive data and statistical inferences.

I am grateful to the principals, physical science teachers and learners of the secondary schools in Orange Farm, Johannesburg for their cooperation during the data collection stage of this study.

My heartfelt thanks need to be accorded my family for the enormous support and prayers throughout my work on this thesis.

Finally, to the one and only God, supreme and sovereign, for the perseverance, energy and spirit of wisdom and understanding.

SUMMARY

This dissertation is based on a four year longitudinal study into learner experiences of transition from Natural Science in the General Education and Training (GET) band to Physical Science in the Further Education and Training (FET) band at a time of curriculum change in South Africa.

The progress and experiences of sixty-one learners from a township school were followed from grade 9 to grade 12. These learners were a unique cohort. They were in grade 1 when Curriculum 2005 (C2005) was introduced in 1997 and they were schooled under this curriculum throughout the GET phase. When they entered the FET phase, C2005 had been replaced by the National Curriculum Statement (NCS).

The study employed a mixed –methods approach. Data were collected using document analysis, an interest questionnaire, lesson observations, examinations, a test on the nature of science, a diagnostic test in chemistry as well as interviews with learners.

The study revealed that the transition was characterized by misalignment of not only content knowledge but also assessment practices. Content was not prescribed by C2005, but reintroduced in the NCS. Learners entered the FET phase whilst lacking basic scientific knowledge. Not even the exit level national examination of the GET phase assessed knowledge of basic science concepts required as a foundation for the FET phase. Furthermore, the emphasis on continuous assessment during the GET did not prepare the learners for the challenges of studying for tests and examinations.

The learners experienced the transition as very difficult. Initially, there was an increase shown in interest in Physical Science from grade 9 to grade 10, particularly amongst boys, but this interest declined as learners progressed to grade 12. They performed poorly, demonstrated poor conceptual understanding and poor problem solving skills. Most learners lamented loss of the closer student-teacher relationships of the GET phase, expressed disappointment with the teacher centred teaching strategies and the lack of opportunities to do practical work. In fact, they ascribed their difficulties to the lack of practical work. They managed this transition through desperate means: they resorted to rote learning, algorithmic problem solving and ultimately, most learners chose careers not involving Physical Science.

I contend that the 2005 Grade 9 Natural Science learners were greatly disadvantaged by C2005 that did not prepare them adequately for Physical Science in the FET phase.

Although this study was limited to one school, it provided insight into learners' experiences of disappointment and difficulties to cope with challenges for which they were not prepared. The study highlighted the importance of matching curricula across phases at times when curricula are changed.

(Key words: transition, transfer, Natural Science, Physical Science, Curriculum 2005, National Curriculum Statement)

ACRONYMS AND ABBREVIATIONS

C2005	**Curriculum 2005**
CS	**Commercial Sciences**
DNE	**Department of National Education**
DoE	**Department of Education**
FET	**Further Education and Training**
GDE	**Gauteng Department of Education**
GET	**General Education and Training**
IQNSFS	**Interest Questionnaire for the Natural Science Field of Study**
JC	**Junior Certificate**
LOLT	**Language of learning and teaching**
LS	**Life Sciences**
MS	**Mathematical Sciences**
NATED 550	**National Education 550 (Résumé of Instructional Programmes in Public Ordinary School)**
NCS	**National Curriculum Statement**
NOS	**Nature of Science**
NSC	**National Senior Certificate**
NSKS	**Nature of Scientific Knowledge Scale**
OBE	**Outcomes Based Education**
PS	**Physical Science**
REQV	**Relative Education Qualification Value**
RNCS	**Revised National Curriculum Statement**
SACE	**South African Council of Educators**
StatsSA	**Statistics South Africa**

CONTENTS PAGE

HEADING **PAGE**

HEADING **PAGE**

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

HEADING **PAGE**

Chapter Four: Results – Quantitative data

Chapter Five: Results – Qualitative data

HEADING **PAGE**

LIST OF FIGURES

HEADING **PAGE**

LIST OF TABLES

HEADING		PAGE

HEADING **PAGE**

LIST OF APPENDICES

HEADING **PAGE**

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

In 1997, Outcomes Based Education (OBE) was introduced to South Africa amidst much publicity (Sanders, 1999). The new curriculum, known as *Curriculum 2005*, was described as one of the most liberal and adventurous education frameworks in the world (Malcolm, 2000). According to this new approach, content was not prescribed, while teaching would be more learner-centred, activity-based and flexible. The curriculum had, however, only been introduced from reception year to grade 9 in the General Education and Training band (GET) by the end of 2005. Curriculum 2005 (C2005) soon ran into difficulties that threatened the survival of the new approach (Jansen, 1997; Tema, 1997). Teachers complained of lack of support, poor training, complex curriculum design and the pace of implementation (Chisholm, 2000; Marnewick & Spreen, 1999; Taylor & Vinjevold, 1999).

In 2002, content was reintroduced in a revised curriculum, the Revised National Curriculum Statement (RNCS) (Department of Education (DoE), 2002a). The RNCS was later renamed the National Curriculum Statement (NCS) and introduced for the first time in the Further Education and Training (FET) band in 2006. The FET is grade 10 to grade 12. The 2005 grade 9 cohort was therefore the last to complete C2005 in grade 9 and the first to enter the NCS in grade 10, complicating the transition to the FET phase. The transition to the NCS represented a potentially serious challenge for both educators and learners because it was discontinuous and inconsistent with the curricula with which educators and learners were familiar.

The curriculum that was in place in South Africa before the democratic government came into power in 1994 was described as prescriptive, content-heavy, teacher-centred, detailed and authoritarian (Ntshingila-Khosa, 2001; Jansen, 1999; Nekhwevha, 1999; Christie, 1993). Many non-governmental organisations (NGOs) had been involved for almost three decades in trying to improve science education in secondary schools in South Africa (Rogan & Gray, 1999). Despite these efforts, the country still has poorly trained teachers, teacher-centred approaches, student passivity and rote learning (Arnott, Kubeka, Rice & Hall, 1997). The majority of schools remained disadvantaged 15 years after democracy, due to a persisting legacy of the apartheid school system (Carnoy & Chisholm, 2008; Hartshorne, 1992).

1.1.1 The scope of the study

This study focused on a transition from one phase in education to another, at a time of curriculum change in South Africa. I am a subject advisor in Physical Science and it is with this background that I undertook a four year longitudinal study of how learners experienced the transition from Natural Science in the GET band to the Physical Science in the FET band. It was a puzzle how learners would negotiate the transition, in circumstances where only 5.4% of teachers had been prepared in their initial teacher education for C2005 and its later revisions (Erasmus & Mda, 2008). Learners in this study had been exposed to OBE up to grade 9 while their teachers in grade 10 had just undergone a two weeks training on the NCS that had to be implemented for the first time in their grade 10 year. The study involved learners from two Black township schools in the Gauteng province of South Africa, both with a similar socio-economic background.

There is little literature on transitions from one phase of education to another, and a serious lack of longitudinal studies that follow the same learners throughout the period of their schooling (Galton & Morrison, 2000). Filling this gap also provided motivation for this study.

Regarding terminology, the terms ‘teacher’ and ‘educator’ were used interchangeably, as were the ‘student’ and ‘learner’.

1.1.2 Transition problems in schools

There is general agreement that transition problems do exist and that they need a joint effort by all stakeholders to deal with them uniformly (Brown, Amwake, Speth & Scott-Little, 2002; Yeboah, 2002). Kagan and Neuman (1998) define ‘transition’ as the experiences that children have between periods and between spheres of their lives. This means that for successful transition to take place there has to be continuity between the primary school and the secondary school, and in the case of this study from the GET phase to the FET phase.

According to Halpern (1994), the ultimate goal of transitions is to create opportunities for lives that are characterised by personal fulfilment. Halpern views transition as an ongoing process from childhood into adulthood and further argues that to deal effectively with the challenges of the new environment, the learner should acquire knowledge, skills and values demanded in the new setting. Patton and Dunn (1998) mention comprehensive planning as one of the key elements to successful transitions. For the transition from the GET to the FET phase, it would mean that the more the GET educator knows about the receiving environment, the better the chances for creating opportunities for effective transition to this new setting. There should be continuity in philosophies, curricula and ethos of Natural Science in the GET band Physical Science in the FET band.

Transition can also be seen in terms of 'border crossing', a metaphor first used to describe the difficulties facing students whose race and thus culture were different from those of the dominant group (Giroux 1992). Aikenhead (1996) applied the work of Giroux to school science by suggesting that when students learn science they often cross a cultural boundary from the sub-culture of their peers and family into the sub-culture of science. Difficulties encountered may be conceptualised as hazards to border crossing. Cobern and Aikenhead (1998) categorized border crossings as smooth, managed, hazardous and virtually or almost impossible depending on the degree of difficulty with which a crossing into a new sub-culture is accomplished. The transition from the GET science to the FET science could be viewed as border crossing from the sub-culture of the outcomes-based GET science to the sub-culture of the content-based FET science.

Transition problems are caused by a number of factors which, if not aligned, may cause anxiety and frustration for the learner (Jewett, Tertell, King-Taylor, Parker, Tertell & Orr, 1998; Mangione & Speth, 1998; Ramey & Ramey, 1998). The transition stage is the time when learners have to cope with changes and challenges, with success measured by their ability to adjust to the new situation. However, the question arises as to how well prepared are those in charge of the learners, i.e. the teachers. Have they been adequately equipped to help learners cope with their transition through the new curriculum? To answer the question it is first necessary to examine the profile of public school teaching in the Republic of South Africa (RSA), with particular reference to the Gauteng province.

1.1.3 The profile of public school teachers in the Republic of South Africa

The study of transitional problems in education needs to take into account the profile of teachers as they should lead learners through transitions. It is for this reason that I looked into the teacher population dynamics, teachers' level of education, teacher attrition, appointment of teachers and their preparedness for the new curricula.

Population distribution

The racial profile of the profession reflects the demographic profile of the country (Carnoy & Chisholm, 2008). Figure 1.1 shows the proportion of teachers within public ordinary schools by race in 2005.

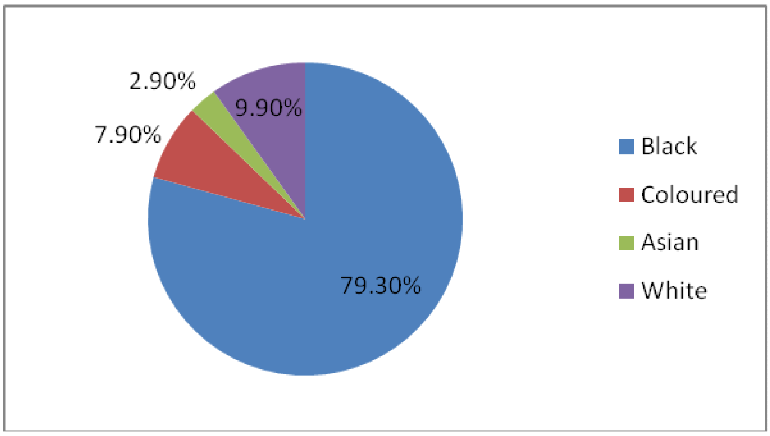


Figure 1.1 Race distribution in the ordinary school sector in 2005 (Arends, 2008)

In 2005 there were 292 484 Black (African) teachers (79.3%), 36 388 White teachers (9.9%), 29 095 Coloured teachers (7.9%) and 10792 Asian teachers (2.9%) (Arends, 2008). The 2005 gender distribution shows that female teachers made up 67.2% and male teachers made up 32.8% (Erasmus & Mda, 2008). The gender distribution in Gauteng also indicated that women dominated the profession. While it is the smallest province (only 1.4% of the land area), Gauteng is the most populous of South Africa's 9 provinces with a population of 9.6 million people (20.2 % of the total population of 47.9 million). With a teacher population of 60 121 in 2005 in the ordinary public schools, 72.1% were female and 27.9% were male (Carnoy & Chisholm, 2008).

Teachers' level of education

The Relative Education Qualification Value (REQV) attached to an education qualification is based primarily on the number of recognised prescribed full-time years of study (Carnoy & Chisholm, 2008). The Matriculation value is REQV 10, while higher diplomas plus bachelor degrees have an REQV value of 14. All three-year diplomas are at REQV level 13, and all honours, masters and doctoral degrees have an REQV level of 14, 15 and 16 respectively. According to the Norms and Standards for Educators that was published in 2000, a teacher with a three-year post-school qualification (REQV 13) is regarded as adequately qualified (DoE, 2005(a)). The National Policy Framework for Teacher Education (2007) set the minimum entry level at REQV 14 for all new teachers joining the teaching profession. Nationwide, 47.9% of teachers had an REQV 14 qualification in 2004 and 37.4% had an REQV 13 qualification while 14.7% were under-qualified as they had an REQV 12 or lower qualification (Carnoy & Chisholm, 2008).

Teacher attrition and shortages

The teacher attrition rate was estimated at between 5 and 5.5% nationally in 2005 (DoE, 2005, p.54). However, the analysis of DoE, the South African Council of Educators (SACE) and Statistics South Africa (StatsSA) figures at an aggregate level seem to suggest that there is no shortage of teachers (Arends, 2008; Erasmus & Mda, 2008). It must also be pointed out that this aggregated data belies the shortage of specific categories of teachers. There are few qualified teachers in the Foundation Phase, Mathematics, Science, Technology as well as Economic and Management Sciences (EMS) (Carnoy & Chisholm, 2008).

A study of 2003-2005 EMIS data by Arends (2008) compares the number of subjects or learning areas taught and the number of teachers with a formal qualification in them (Carnoy & Chisholm, 2008). In 2004, more teachers in Gauteng were teaching in learning areas than were trained in those learning areas, regardless of school type (primary, combined or intermediate and secondary) and regardless of teaching level (foundation, intermediate and senior). This suggests that teachers not trained to teach specific subjects such as Natural Science were doing so. The reasons for this misallocation are not clear. The Gauteng Department of Education (GDE) is attempting to co-ordinate the supply and demand of teachers at local level through planning around the post-provisioning model (Carnoy & Chisholm, 2008).

Appointment of teachers

According to Carnoy and Chisholm (2008), there are two types of posts available to teachers in schools. The majority of posts are provincially-funded, referred to as "funded posts", the others being SGB posts that are established and paid for by the School Governing Body (SGB) over and above the allocation of provincial posts to schools. Poorer schools are less able than more affluent ones to afford SGB posts or teachers who are paid out of income from school fees from parents. The poorer schools are more dependent on the "vacancy" and "excess" lists created and managed by district offices for their teachers (Carnoy & Chisholm, 2008). A "vacancy" is created when a vacant post exists. An "excess" list is made up of names of permanently appointed teachers who have been declared additional to their schools' post establishment due to operational requirements, e.g. if the subject that the teacher is offering has been phased out at that particular school, or if there has been a drop in learner numbers with the resultant new post establishment of the school offering fewer posts.

Preparedness for new curriculum

The mean age for practising teachers was 41 in 2005 (Stats SA, 2006) and 5.4% of all practising teachers were under the age of 30 in 2005 (Arends, 2008). According to Erasmus and Mda, if only 5.4% of all those practising were under the age of 30 in 2005, it can be assumed that only 5.4% had been prepared in their initial teacher education for C2005 and its later revisions. This implies that the majority of teachers were not prepared for the new curriculum by their formal teacher training, and in most cases may not have had the skills needed to interpret and implement the new curriculum.

1.1.4 The plight of learners in transition to the FET phase

High rates of failure in secondary school science classes are a problem worldwide (Fonseca & Conboy, 2006). In southern Portugal the failure rate for all secondary students is most prominent in grade 10 (Carreira & Andre, 2000).

The lack of continuity and progression between primary and secondary education has been an issue for several decades in the United Kingdom (UK) (Davies, 2004). The Observational Research and Classroom Learning Evaluation (ORACLE) project (1975-1980) and its replication study (1996) found low levels of expectation by secondary teachers of learners' enquiry skills in the first year of secondary school in the UK (Galton et al., 1999).

Similarly, there is a general perception in Botswana, Lesotho and Swaziland that the achievement of learners in O-level is below the expected level compared to their achievement in the Junior Certificate (JC) examination (Manyatse, 1996). This was attributed to a gap between JC and O-level, one example of a phase transition in education.

School records available from the Department of Education (DoE) provide little direct information on grade repetition (Anderson, Case & Lam, 2001), especially during the 1990s. Records are available, however, for the 2000s. In the Gauteng province of South Africa, the rate of repetition in grade 10 is the highest (refer to Table 1.1).The Ministry of Education also noted in 2008 that there was a significant school dropout rate after grade 9 (Mail & Guardianonline, 2008). This seems to suggest that learners in grade 9 may not have acquired enough content knowledge to cope with knowledge demands of grade 10.

The question arose as to whether this high failure rate could be due to transition problems experienced by learners from the GET to the FET phase.

The current study investigated the transition from science in the GET phase to science in the FET phase. I investigated how the transition can be characterized, how learners experience the transition itself, and how their strategies and approaches to negotiating the transition could be understood and explained. To my knowledge, no empirical study has been conducted in South Africa to try to characterize the transition from the GET phase to the FET phase, especially with respect to the learning of the natural sciences.

Table 1.1 Repetition by grade (GDE, Annual Report 2004/2005)

Percentage (%) Repetition				
Grade	2001	2002	2003	2004
1	4,3	4,2	4,4	4,2
2	3,3	2.9	2,9	2,8
3	3,3	2,7	2,5	2,6
4	3,4	2,9	2,7	2,6
5	3,7	2,2	1,8	2,0
6	2,6	2,2	1,3	1,5
7	1,1	0,9	0,9	1,3
8	2,1	3,4	4,3	4,2
9	9,0	4,9	5,6	5,3
10	**14,4**	**16,1**	**19,9**	**18,0**
11	13,2	14,3	14,6	15,3
12	1,6	1,5	1,2	0,7
Average	5,21	4,84	5,46	2,96

1.1.5 The plight of GET science educators

The problems faced by the middle school and junior secondary educators in learning and teaching science have been the subject of considerable investigation by the educational research community for over three decades (ASTEC, 1997; Atwood & Atwood, 1996; Wallace & Louden, 1992; Smith & Tilgner, 1990; Neale, 1989; Schoeneberger & Russell, 1986; Mittlefehldt, 1985; Shrigley, 1974, 1977). Large numbers of students enter the GET teaching pre-service course with very little science background (Fensham et al., 1991), and they are concerned about studying science themselves and teaching it to children. GET science educators often claim that they lack the time and knowledge to organise science activities and resources (Scott, 1989) and argue that they have negative experiences with group work and classroom management when teaching science (Goodrum, Cousins & Kinnear, 1992). GET teachers appear to be caught in a dilemma between making science more accessible to their learners and delivering the products of science (Abell, 2002). In summary, poor science background of teachers, combined with the low-status culture of science in schools offering the GET learning areas, confusion about teachers' roles and the lack of science teaching role models complicates transition of learners from GET science to FET science.

As I am interested in the study of transition from the GET to the FET bands, a brief overview of these two bands is given below.

1.2 THE GENERAL EDUCATION AND TRAINING BAND

The GET band comprises Foundation Phase (grades 1-3), Intermediate Phase (grades 4-6) and the Senior Phase (grades 7-9). I am interested in the Senior Phase learner who has to make a transition to the FET band (grades 10-12).

The Natural Sciences in the GET band consists of four themes namely Energy and Change, Life and Living, Matter and Materials, Earth and Beyond. Three of these themes, Energy and Change, Matter and Materials as well as part of Earth and Beyond progress to Physical Science in the FET band. Life and Living progresses to Life Science and part of Earth and Beyond progresses to Geography. The content knowledge chosen by teachers and teaching approaches for the Natural Sciences in the GET band aim to achieve the prescribed Learning Outcomes. It will be helpful to look at the profile of the GET graduate who seems to be struggling in grade 10 as evidenced by the repetition rate in grade 10 (Table 1.1).

The Senior Phase learner is able to reason more independently about concrete materials and experiences (DoE, 1997). S/he is also able to engage in open argument and is willing to accept multiple solutions to single problems. There should be clear evidence that the learner is being prepared for life after school, i.e. life in the world of work, at institutions for further learning and for adult life in general. Learning programmes should create opportunities for the learner to be informed about career and further learning opportunities, about ways and means of realising his/her expectations for the future, and about his/her rights and responsibilities as a citizen in a democratic, multicultural society (DoE, 1997).

According to Halpern (1994), comprehensive planning, a key element to successful transition, includes a thorough needs analysis that should take into account the needs of the individual and the setting into which the individual will be going. It is therefore important for both the educator and the GET learner to know the setting (FET band) which s/he will be entering.

1.3 THE FURTHER EDUCATION AND TRAINING BAND

It is at this level that learners are to be prepared for higher education, vocational education, careers and self-employment. Various providers are involved in this band of education and training, e.g. senior secondary schools, technical colleges, NGOs, regional training centres, private providers and private colleges, private training centres, private companies, industry training centres and community colleges. This band is not compulsory (DoE, 1997).

The National Qualification Framework (NQF) is a framework for registering qualifications at specific levels and developing learning paths between them. It has 8 levels that are divided into three bands, namely, GET (level one), FET (levels two to four) and Higher Education (levels five to eight). The development of unit standards and curriculum for this band has to be carefully co-ordinated, as the NQF is based on the principle of integration of education, and the accumulation of credits across different institutions. These credits can consist of core units and optional units in combinations, undertaken in a variety of modes (DoE, 1997).

1.4 MOTIVATION FOR THE STUDY

Education in different countries around the world is designed in different phases, namely, pre-primary, primary, secondary and tertiary phase. In South Africa it is organised into Early Childhood Development phase, Foundation phase, Intermediate phase, Senior phase and the Further Education and Training (FET) phase.

In this study, my interest is in the transition from the Senior Phase (grade 9) to the FET phase grade 10) and throughout the FET phase. Remaining a problem is the way learners negotiate these transitions, successfully in many cases, from one phase to another. Coupled with this is the question of content and conceptual understanding, which is troublesome in an OBE set-up. Broad learning outcomes, such as *problem solving in innovative ways* or *understanding concepts, principles and acquired knowledge in the Natural Sciences* (Curriculum 2005), do not, of themselves, recommend particular content. Yet content is very important. Questions of the choice and sequencing of content in the curriculum are being tackled as serious research questions around the world (Fensham, 1999; Malcolm, 1999). These are questions that have also interested me as a subject advisor for Physical Science and an examiner for the Senior Certificate (grade 12 Physical Science) in the GDE. Furthermore, there is insufficient literature on longitudinal studies that follow the same learners throughout the period of their schooling (Galton & Morrison, 2000).

1.5 PROBLEM STATEMENT

Against the above background, the study explored the transition from Natural Science in the GET phase to Physical Science in the FET phase from 2005-2008. The following research questions were formulated:

i. How can the transition from the Natural Science in the GET phase to Physical Science in the FET phase be characterized?

ii. How do learners in the Gauteng province of South Africa experience the transition from Natural Science in the GET phase to Physical Science in the FET phase?

iii. How can the learners' strategies and approaches for negotiating the transition be understood and explained?

1.6 AIMS OF THE STUDY

This was a four-year longitudinal study that aimed to characterize the transition from GET science to FET science, and to understand and explain how learners experienced and negotiated the transition from 2005-2008. It is hoped that the study will make a valuable contribution to the literature on transitions in education.

1.7 ORGANISATION OF THE CHAPTERS

In Chapter 2, I reviewed the literature that is relevant to the study, under the following topics: Curriculum 2005; implementation of C2005 in Natural Science; previous studies on transition in education; and the theoretical framework. The chapter concluded with directions for the research emanating from the literature review.

In Chapter 3, I gave an overview of the mixed methods approach and research instruments used in the study, namely document analysis, questionnaires; classroom observation, examination results, a diagnostic test and interviews.

In Chapter 4, I first discussed the results of the 2007 grade 11 Physical Science examination and then analysed the quantitative data emanating from the interest questionnaire, the Nature of Science questionnaire and the diagnostic test.

In Chapter 5, I analysed and discussed the qualitative data emanating from documentation, classroom observation and interviews.

In the last chapter, Chapter 6, I revisited the research questions gave the conclusions of the study. The chapter ended by pointing out the limitations of the study, directions for further research and implications for science education, with some recommendations made.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews literature on transitions in education, transitional problems, suggested solutions and studies in South Africa and abroad. Motivation for studying transition in science education in particular is also given. The chapter ends with a discussion of the theoretical framework and a summary of the literature review.

2.2 INTERNATIONAL STUDIES

The words *transition* and *transfer* are key words in the discourse that follows. 'Transition' refers to the move from one year to another within the same school, while 'transfer' refers to the move from one stage of schooling and from one school to another (Demetriou, Goalen & Rudduck, 2000). I have noticed, however, that the two words may be used interchangeably in the literature on transition.

Transfer and transition are difficult issues to write about for an international audience, given the diversity of organisational structures in the education systems of different countries. In this study I note four major systemic transitions (or transfers), namely home to school, elementary (primary) to middle/junior high school, middle/junior high school to high school and high school to tertiary institutions or work. The fact that a learner has successfully negotiated one transition does not mean he or she will successfully negotiate the next one (Simmons & Blyth, 1987).

Learners must successfully negotiate the four major transitions mentioned if they are to be successful in the long run (Anderson, Jacobs, Schramm & Splittgerber, 2000). It is in the light of this observation that transition from the GET band (grades 0 to 9) to the FET band (grades 10 to 12) in South Africa will include a discussion of systemic transitions from elementary (primary) to middle/junior high school and from middle/junior high school to high school. The focus of the study is, however, on transition from grade 9 Natural Science to grade 10 Physical Science and progression through the FET phase.

2.2.1 Transition and transfer problems across the world

Transition between different institutions and phases of education is always important. It is important that, even though learners may move school, they do not experience discontinuity in the curriculum. This is particularly so between the last year of an institution or phase and the first year of the next institution or phase. A discussion of transition and/or transfer problems around the world follows.

The Kingdom of Swaziland

Swaziland is a small country situated between Mozambique and South Africa, with secondary school education divided into junior secondary and senior secondary (high school) phases. The junior secondary phase lasts three years and the senior secondary phase lasts two years. Each of these phases has a public examination in its final year. Learners sit for the Junior Certificate Examination (JC) in the third year of the junior secondary phase. The JC examination is administered by the Lesotho and Swaziland Examinations Council. At the end of the high school phase the learners sit for an examination known as the Ordinary level (O-level) administered by the University of Cambridge Local Examinations Syndicate (UCLES) (Manyatse, 1996).

Many stakeholders in the education system of Swaziland complained of a gap between the junior and senior secondary phases of schooling, particularly in the sciences. The public based its perception of the gap on external national examinations (JC and O-level examinations), while the teachers themselves based their perception on the basis of the teaching and learning processes in the classroom. The gap in science was not only perceived in Swaziland but also in Lesotho and Botswana, which also have a JC external examination (Manyatse, 1996).

An empirical study to identify the nature of the perceived gap was undertaken by Manyatse, (1996). Some of his findings were:

- There was no gap between the syllabuses and curriculum materials at the two levels (JC and O- level).

- There was a gap in terms of balance and testing of cognitive levels between the exams at the two levels.
- A conceptual teaching approach could improve the understanding of the particulate nature of matter.
- Detailed teaching materials might influence the teaching approach of teachers, that is, specially designed teaching materials that are more user-friendly than the textbooks can be produced to influence the teaching approaches of teachers.

The United Kingdom (UK)

Progression and continuity are cornerstones of the curriculum, according to Braund and Hames (2005). They noted that one of the most significant changes in the curriculum since the introduction of the National Curriculum in England and Wales in 1989 had been the rapid development of science in the primary school. The implications of such a development for continuity and progression throughout age 5 – 16 (Years 1 to 12) schooling in science and especially at the primary-secondary interface (Years 6 and 7) were recognised in a very influential government policy statement in the run up to the introduction of the National Curriculum (Braund & Hames, 2005):

> *The development of science in primary schools imposes an added responsibility on the schools to which the pupils transfer: they have to ensure, if the goal of making science from 5 to 16 a continuum is to be realised, that pupils' early start is neither ignored nor undervalued but rather reinforced and exploited in their subsequent work. Suitable arrangements for ensuring continuity and progression are therefore essential (Department of Education and Science/Welsh Office, 1985: 11, para 32).*

Braund and Hames (2005) noted that twenty years later and 15 years after the implementation of the National Curriculum, this goal had not been achieved. As many as forty-percent of the learners failed to make the progress in early secondary school predicted by their primary school performances. (Galton, Gray & Ruddock, 1999).

Some studies show that learners obtain lower scores when they are re-tested in secondary school using the same questions put to them previously in the primary school (Bunyan, 1998;

Nicholls & Gardner, 1999). Braund and Hames (2005) offer two kinds of explanations for this decline and for the fact that it is worse for science:

- A new, larger and more challenging environment, new friendship groupings, more teachers and new rules all make demands on incoming learners.
- The 'shock of the new' for learners after transfer, in terms of changes in pedagogy, may have a much more significant and long-term impact on learners' learning in science and on their attitude to the subject.

Literature on the transition over the primary-secondary interface suggest the following factors that are particularly important in relation to post-transfer regression and early decline in learners' attitudes to school science:

- Learners may repeat work done at primary school, often without sufficient increase in challenge, sometimes in the same context and using similar procedures (Galton et al., 1999; House of Commons Committee, 1995; Secondary Science Curriculum Review, 1987).
- Teaching environments, styles of teaching and teachers' language are often very different in secondary schools compared to primary schools. They represent a change in the culture of teaching and learning to which learners have difficulty adjusting (Hargreaves & Galton, 2002; Pointon, 2000).
- Teachers in secondary schools often fail to make use of or refer to learners' previous science learning experiences. Information supplied by primary schools on their learners' previous achievements is rarely used effectively to plan curriculum experiences in the secondary school (Braund, Crompton & Driver, 2003; Nicholls & Gardner, 1999; Schagen & Kerr, 1999; Doyle & Hetherington, 1998).
- Teachers in secondary schools do not trust the assessed levels of performance gained by learners in national examinations in science taken by learners at the end of primary school. Secondary school teachers often claim that these levels have been artificially inflated by intensive revision for these examinations (Schagen & Kerr, 1999; Bunyan, 1998). This may be used by secondary school teachers as justification for starting afresh when planning new learning (Nott & Wellington, 1999).

Studies elsewhere have identified similar problems e.g. in the United States (Anderson et al., 2000) and Finland (Pietarinen, 2000).

The United States of America (USA)

In the USA, researchers explored the reasons why transitions were difficult, the kind of learners that had the greatest difficulty with transition and the process of disengagement from school that too often followed unsuccessful transition. They focussed on the systemic transition from elementary to middle/junior high school and middle/junior high school to high school. Systemic here meant "systematically built into the typical structure of public school systems" (Rice, 1997, p. 1)

School transitions interrupt the continuity of life (Anderson et al, 2000). As learners move from one school to another (e.g. from middle/junior high school to high school), they are confronted with:

- An increase in the physical size of the new institution and the number of learners (Roderick, 1993)
- Increased differentiation of the learner population in terms of racial, ethnic and class diversity (Roderick, 1993)
- A greater emphasis on relative ability and competition (Schumaker, 1998)
- A more detached relationship with teachers (Mizelle, 1995; Wells, 1996)

The negative impact of systemic transitions on self-esteem tends to be greater for girls than for boys (Crockett, Peterson, Graber, Schuleners & Ebata, 1989; Blyth, Simmons & Bush, 1978). This decline is exacerbated by other life changes, such as the onset of puberty and divorce of parents (Simmons & Blyth, 1987). Learners with behavioural problems in primary school tend to have more difficulty in making the transition to middle/junior high school (Anderson et al, 2000). This lack of academic preparedness is evidenced by low scores on tests (Roderick, 1993).

The failure to successfully negotiate systemic transitions may initiate the gradual disengagement process from school and promote conflict between the affected learners and the school (Roderick, 1993). This gradual disengagement process may even lead to dropping out of school as the final step (Finn, 1989).

Finland

A study conducted in Finland by Pietarinen (2000) sought to explore and explain the experiences of Finnish comprehensive school learners as they transferred from the primary to the secondary school and as they studied in the latter institution. These learners were asked to describe their experiences of grades 6, 7 and 9. This longitudinal research setting made it possible to collect data dealing with the experiences of the same learners at key moments in transfer, that is before the transfer, at the end of the first year at secondary school and at the final stages of comprehensive school (Pietarinen, 2000). Two-thirds of the learners studied experienced some disappointments, problems and fears, which were expressed individually in their daily schoolwork. Asked about her experiences, one grade 9 girl responded as follows:

> *"Teaching has been quite boring at secondary school, quite different from what it was at primary school. At primary school we had more possibilities to take part in action, here it's mainly the teachers who just teach. Fortunately there has been some variation in some subjects. My study habits have also changed at secondary school. When I was at primary school the homework was always to be done and it was really done at home. If I say that I do so nowadays, I am lying. No, nowadays studying is mainly that one finishes off the homework right before the class starts. Here at secondary school one is more responsible oneself for one's own study than at primary school. In primary school teaching, there wasn't probably much that has supported study at secondary school. It's so different to study here. Yet there haven't been too many problems concerning study at secondary school. The only thing may be that when there is a new teacher in practically every class it is so easy to skip classes, which I did a lot at one point. So my grades dropped ...It's my own fault of course; here I am, living my youth, the best time in one's life, there are so many other things that are more interesting than school."* (Pietarinen, 2000, p. 390).

A sign of a teacher's professionalism remains the ability to analyse these experiences and determine which of them have relevance for developing a comprehensive, unified system (Pietarinen, 2000).

New Zealand

In New Zealand, the traditional transition school for most pupils is the Intermediate School, which caters for Years 7 and 8, and features the typical classroom teaching of primary schools with some additional specialist teaching. In this way learners are offered the continuity of the familiar integrated curriculum delivery model, while introducing specialist teaching characteristic of secondary schools. The most significant change occurred when the Intermediate Schools were extended to include Years 9 and 10, thus becoming four-year middle schools and delaying the transition by two years (Ward, 2000).

A discussion on studies on transition from different perspectives follows.

2.2.2 Studies of transition in science from a curriculum perspective

The transition in science from a curriculum perspective was examined by Weston et al. (1994), who made a study of Advanced (A) level and GCSE chemistry syllabuses. The results of a questionnaire, sent out to a large number of schools and colleges in England and Wales, showed that although there was no apparent gap in the syllabuses there was a perception that the GCSE science course was an inferior form of preparation for A level. This study again points to the inescapable tension within a course that tries to serve two types of clients: those who wish to continue (the minority) and those who wish to terminate (the majority) (Rollnick, Manyatsi, Lubben & Bradly, 1998).

Conflicting aims to teaching science

Problems in transition are not encountered in the subject of science only. What then, could have made the study in science more interesting to me? The conflicting aims to teaching science, the very nature of science and the different epistemological beliefs as well as my own science background were the motivating factors.

There are two fundamental aims to teaching science that are in conflict with one another (Black, Harrison, Osborne & Duschl, 2004; Weston, Lazonby & Tomlins, 1994). Traditionally, the science curriculum has been a pre-professional method of preparing the next generation of scientists. The curriculum that serves this aim begins with the foundations of science that address the basic concepts in a piecemeal fashion and then build additional layers of knowledge upon them. Any sense of depth and coherence is only obtained after many years of formal study. In addition, the knowledge that forms the substance of such a curriculum is seen to be well established, unequivocal and indubitable. Consequently, there is a tendency for much of the subject to be taught in an authoritarian manner, leaving little space for discussion or exploration of what, after all, is a set of unnatural and difficult ideas. One of the unfortunate results of this approach is that learners are left with a particular epistemological standpoint, a strong impression that science produces certain and absolute knowledge of the real world. Little chance, if any, is given to explore the uncertainties and tentative nature of the knowledge produced by science. Such knowledge is important if learners are to understand the tremendous contributions of the scientific endeavour (Black et al., 2004).

On the other hand, there are those who argue that science should be compulsory for all, the major rationale for this being the view that the pervasiveness of science within society requires all learners to be educated about it until age 16 (Black et al., 2004). However, this aim is, best served by a fundamentally different curriculum and approach, that is one that gives much less importance to content and places more emphasis on teaching *about* science. From this perspective, the major explanatory themes should be presented in a contemporary context that offers improved relevance and an opportunity to explore and appreciate both the intellectual achievement of science and its cultural importance. This approach would allow the exploration of the ways decisions about science and technology affect society, the nature of risk and its assessment, the mechanisms by which scientific ideas are judged and evaluated and the role of models in science (Black et al., 2004). It is my view that the Natural Science curriculum of the GET phase under Curriculum 2005 was meant to serve this aim.

The essential tension is that the school science curriculum has to develop an adequate knowledge base for those who wish to pursue the study of science beyond the GET band, while also attempting to develop an understanding about science necessary for society. In other words, the compulsory science curriculum is battling with the competing demands of the requirement that science education should provide training for the next generation of scientists on the one hand, and the needs of the majority for a broader scientific education on the other. These aims are often in conflict with one another and undermine the effectiveness of the science curriculum in achieving either aim (Black et al., 2004). This tension between teaching science for the sake of society, or for the sake of scientists, is the essence of the transitional problems between the GET and FET in the current study.

The nature of science

Understanding the nature of science has been regarded as one of the basic requirements for scientific literacy. In Science for all Americans (American Association for the Advancement of Science, 1989), the meaning and importance of the nature of science is extensively described. Duschl (1990) argued that educators' view of scientific theory is likely to be related to their method for selecting content and instructional strategy. This relationship has been further confirmed by Brickhouse (1990), Gallagher (1991) and Lederman and Zeidler (1987).

What science educators teach depends firstly on their scientific understandings and skills, on what they are able and willing to teach and on what they believe they are required to teach (Rens & Dekkers, 2001). Curriculum reform depends largely on the educators. Although it is not the aim of the current study, it is important to find out whether their understanding of the nature of science is in accordance with what they are required to teach (Dekkers & Mnisi, 2003). This will help determine the readiness and competence of the educators to deal with transition problems of learners in the field of natural sciences.

The relationship between student science learning and their understanding of the nature of science has caught the attention of science educators. It was found that students' views of science are significantly related to their knowledge integration and learning orientation methods (Songer & Linn, 1991; Tsai, 1998). Regarding my study, learner's knowledge integration and learning orientation may be related to their strategies and approaches for negotiating the transition, shedding light on research question 3.

The DoE (2002(b)) contends that one of the underlying differences between modern science and technology on the one hand and traditional and indigenous knowledge systems on the other hand, is the existence of different worldviews, with empiricism as the basis of the prevailing worldview of science. Empiricism claims that if something can be observed and measured in some way, it is real and can be used to explain how events happen in nature

(DoE, 2002(b)). Another worldview is that people are not separate from the earth and its living things, and that they believe all things have come from God or a creative being, and therefore have spiritual meaning. Traditional and indigenous knowledge systems and technologies have developed within this system of thought (DoE, 2002(b)). However, there is yet another worldview, that of post-positivism, which posits that human knowledge is not based on unchallengeable, rock-solid foundations, but rather is conjectural. Although there are firm grounds for asserting the beliefs that one may hold as a scientist, these grounds are not unquestionable, it may change in the light of further investigation (Phillips & Burbules, 2000). In fact, the Nature of Science includes the tentativeness of knowledge, also called the developmental nature of science (Klee, 1997).

2.2.3 Studies of transition from a learner's point of view

Murphy and Beggs (2001) suggest that the lack of experimental work and intensive preparation for national tests in Britain may contribute to learners' loss of interest in science. The loss of interest in science amongst girls may contribute to the well known phenomenon of girls' lower participation rate in Physical Science (Gerard & See, 2009).

In Australia, Speering and Rennie (1996) found that during transition there was a considerable change in the organisation of the school, the curriculum and the teacher-student relationship. They found that students in their study, especially girls, were generally unhappy with the teaching strategies used in their secondary science classrooms, and that they regretted the loss of the close teacher-student relationship of their primary school years. Their perceptions were that science in secondary school was not what they had expected, and this experience might have long term implications for subject and career choices (Speering & Rennie, 1996).

Again in Australia, White, Gunstone, Elterman, MacDonald, McKittrick, Mills and Mulhall (1995) reported that first year university Physics students found difficulty in adjusting to the teaching approaches at university and were frequently not certain about the functions of the various teaching situations. First-year undergraduates moved from a system where they were closer and had ready access to their educators, whose personalities and methods they knew and who in turn knew them well, and also where they were likely to be questioned and have their understandings monitored, to a system of detachment. There the educators would rarely recognise a student outside the lecture hall as a member of their class, let alone know a name or anything personal about him or her. In addition, interchanges between educator and individual students would be rare and the educators might test and judge students' progress from time-to-time but show students little concern over any lack of progress (White et al., 1995).

Vlaardingerbroek and Ros (1990) studied transition rates of learners in five developing countries where access is controlled between junior and senior secondary school. The movement of learners from one level in the school system to another was defined as the educational transition rate and expressed as the percentage of the cohort at the lower level that had reached the higher level. They set out to present one methodological approach that seemed useful for probing the relationship, if any, between developing countries' educational policies as reflected by transition rates at certain specific points in the school system and the academic quality of students entering senior secondary institutions. Data for testing the approach were obtained by:

- developing a test of basic mathematical ability that was considered a valid criterion for measuring the academic quality of learners entering upper secondary institution
- conducting a comparative study using transition rates and measures of academic quality obtained from five developing countries, namely, Liberia, Kenya, Papua New Guinea, Solomon Islands and Tanzania
- conducting a longitudinal study using transition rates and measures of academic quality obtained across a ten-year period in Papua New Guinea.

They showed that the less rigorous the selection at this point, the poorer the performance in basic mathematics.

2.2.4 Studies of transition from the teacher's point of view

In Great Britain, Dawson and Shipstone (1991) pointed to the positive role played by liaison teachers at the primary/secondary school interface. Some primary schools were engaged in science liaison with secondary schools. Schools could be engaged in science liaison in different ways, for example meetings, staff visits and exchanges, equipment borrowing, inter-school science clubs and joint in-service training (INSET). Both groups of educators (primary and secondary) gave the need for knowing each other's science courses as the most important reason for starting liaison. Primary educators were in particular conscious of having little knowledge of what science was being taught in secondary schools and therefore of being unable to make any accurate assessment of what science they should undertake to help children after transition. Both groups, who also saw liaison as offering mutual support, gave the need for curriculum consistency as an important reason and one leading to involvement of the wider community in the science the children were undertaking. Secondary educators, though, to a much greater extent than the primary educators, saw liaison as offering them the opportunity to improve their understanding of the cognitive needs and development of the children (Dawson & Shipstone, 1991).

Overton and Reiss (1990) highlighted the concern of teachers about a gap at the GCSE/ A-level interface. The General Certificate of Secondary Education (GCSE), a public examination open to students in England and Wales, is usually taken at age 16. It replaced GCE O-level and CSE examinations. Many educators referred to the existence of a 'quantum leap' between GCSE and A-level, some feeling that GCSE was simply an insufficient preparation for A-level Biology. Other educators felt it was time that A-level courses changed in the light of the gap at the GCSE/A-level interface. These educators argued that A-levels should place greater emphasis on process skills, with at least 20-percent practical assessment and a reduced theoretical content. Finally, a third group of educators felt that the leap required to go from GCSE to A-level had been much exaggerated. These educators argued that GCSE students might start A-levels knowing fewer biological facts, but would be better at data handling and more motivated. It is noteworthy that after this study on process skills, there was a decrease in the amount of content to be covered and a shift towards modularisation. These changes were likely to help students who had taken GCSE (Overton & Reiss, 1990).

2.2.5 Suggested solutions to transition problems

The following recommendations for facilitating successful systemic transitions have been made:

Preparedness

Preparedness as a multidimensional concept includes:

Academic preparedness – learners must have the knowledge and skills to succeed at the next level (Simmons & Blyth, 1987).

Independence – learners should be independent and should neither require direct teacher intervention nor direct supervision (Ward, Mergendoller, Tikunoff, Rounds, Mitman & Dadey, 1982).

Conformity to adult standards - learners should conform to adult standards of behaviour (Simmons & Blyth, 1987).

Coping mechanisms – when learners are skilled at using effective mechanisms for coping, they are likely to make successful systemic transitions (Snow, Gilchrist, Schilling, Schinke & Kelso, 1986).

Support

Kurita and Janzen (1996) have identified four types of support, namely:

Informational support – by merely providing learners with information about the transition can help them through it.

Tangible support – providing resources or services to learners can help them through transition.

Emotional support – Emotional support from parents and teachers can help learners through transition.

Social support – having friends at the same school can ease transitional difficulties.

Bridging the gap

Pietarinen (2000) suggests that the starting point for bridging the gap between primary and secondary school and forming a wider, undivided comprehensive school is to locate areas of shared interests. She suggests that these should not be limited to a particular school level but should seek to unite class teachers (from primary school) and subject teachers (from secondary school).

Improving continuity and progression

Studies of transitions from primary to secondary education have been conducted in England by Maurice Galton and his team based at the University of Cambridge. Galton et al. (1999) identified five areas of improvement:

- Bureaucratic: e.g. meetings between staff from primary and secondary schools.
- Social and personal: e.g. induction days, open evenings and the use of learners and parents as guides for new entrants to the secondary school.
- Curriculum: e.g. joint projects and training days for teachers, lessons taught by secondary school teachers in primary schools.
- Pedagogic: e.g. teacher exchanges, joint programmes to develop specific teaching and learning approaches.
- Management of learning: e.g. extended induction programmes in the secondary school that focus on aspects of learning skills, learners' self-assessment, and that recognize how learning in secondary school progresses from that in primary school.

Galton's team carried out a survey of 215 secondary schools in England that revealed that schools invested most effort in the bureaucratic and social or personal areas of action and that a few schools took actions relating to the establishment of curriculum or pedagogic bridges to improve continuity and progression in teaching and learning (Galton et al., 1999).

Bridging work

According to Braund and Hames (2005), a number of strategies are used by schools to address curricular and pedagogical discontinuities. These include:

- Co-observation of teaching.
- Improving teachers' knowledge of content taught each side of transfer (e.g. grade 9 Natural Science and grade 10 Physical Science).
- Shared assessment of learners' work.
- Jointly planned teaching.

It is in the last strategy that much recent attention and effort has been focused. The strategy would be to plan work that learners start at the end of primary school and continue and complete when they arrive at the secondary school (Braund & Hames, 2005). These schemes are described differently as transition units (Qualifications and Curriculum Authority, 2002), link projects (Davies & McMahon, 2004) and bridging units (Braund, 2002). There has been criticism of bridging work, however.

Criticism of bridging work

Galton's main criticism of bridging work can be summarised as follows (Galton, 2002):

- The breakdown of 'pyramids' where well-defined groups of primary schools transfer learners to just one secondary school meant that not all learners entering secondary school science classes would have covered the primary part of the bridging unit.
- Primary school teachers and their learners not being very keen about the use of bridging course material after the stresses of national examinations carried out in the last term of primary school and the revision period that preceded them.
- Primary school teachers not willing or not having time to mark work at the depth that would be helpful in allowing secondary teachers to develop and progress the topic.
- Some learners claiming that they rarely saw the work that had been transferred or that primary work was only referred to superficially and then the secondary teacher returned to the normal work.
- Learners entering secondary school expecting and looking forward to doing new things and leaving behind their primary school experience.

Criticism of the middle school concept

The following objections were voiced against the middle school concept (grades 7 to 10) where transition was delayed by two years in New Zealand included (Ward, 2000):

- Learners who enter secondary school at about age 13 (Year 9) embarked on a four or five year longitudinal program in each subject. As a consequence late entry into the programme (Year 11) interrupted the continuity of the programme's content and skills progression.
- In Year 11, learners sit for the first national examination, the New Zealand School Certificate. Learners who entered secondary school in Year 11 already had sufficient challenges in adapting to a new school environment.

- Learners from middle schools would be inadequately prepared for secondary programmes because middle schools did not have the qualified specialist subject teachers and laboratory resources of the secondary school.
- Middle school learners entering secondary school in Year 11 would find difficulty in being included socially and being part of a substantially different culture.

2.2.6 Attitude towards studies - another perspective on transition

Educational objectives in the affective domain, dealing with attitudes, interests and values, are of great importance and this is almost universally acknowledged (Choppin & Frankel, 1976). According to Schibeci (1984), science-related attitudes are subdivided into two major categories, namely, *attitudes to science* (e.g. interest in/enjoyment of science lessons), and *scientific attitudes* (dispositions such as tolerance of the views of others which scientists are presumed to display in their scientific work).

Researchers use *attitude to science* as a broad category that includes attitudes to science careers, science instruction, specific science issues and scientific processes (Schibeci, 1984). Many studies have reported a decline in attitudes with increasing grade level, including those of Ayers and Price (1975), Bohardt (1975), Johnson (1981), Sullivan (1979) and Yager (1983). Johnson (1981) noted that the decline in attitudes in the USA was more rapid among white students than amongst black ones. However, Aiken (1979) and Hobbs and Erikson (1980) have reported that attitudes did not decline with increasing grade level.

Studies in the USA and Australia show that positive attitudes towards science decrease throughout the school years, with the most dramatic change occurring during the transition from primary phase to the secondary phase (Schoon, Ross & Martin, 2007; Linn & Hyde, 1989). At the end of their primary school years, learners have a great deal of enthusiasm for science and its activities (Baird, Gunstone, Penna, Fensham & White, 1990), but fewer learners express the same enthusiasm for secondary science (Rosier & Banks, 1990). The decline in motivation towards science in secondary school is particularly disturbing as it is likely to have negative effects on the learners' career choices.

2.2.7 Determining transitional success and failure

Researchers have used several indicators, one being student grades, which may be low (Ward et al., 1982), or declining (Roderick, 1993). Ward et al. (1982) identified other indicators, namely the appropriateness of the student's post-transitional classroom behaviour, given the rules and norms operating in the classroom. A third indicator is the student's post-transitional social relationships with peers. A fourth indicator is the student's academic orientation in the post-transition classroom, which can be defined as correctness of oral responses to teacher questions and completion of assignments.

The first and fourth indicators are of most importance in the current study.

2.3 SOUTH AFRICAN STUDIES

Two relevant studies on C2005 are discussed below. In trying to solve problems arising out of the implementation of the C2005 in South Africa, Rogan and Grayson (2003) proposed a theory on the implementation of the learning area Natural Science. The Department of Education (DoE) also commissioned a report on the reasons for the low pass rate in grade 10 in 2003 (Reddy, Dlamini, and Ntshingila-Khosa, 2004).

2.3.1 The implementation of the Natural Science learning area of Curriculum 2005: an emerging theory

South Africa has developed a new curriculum, something not peculiar to the country but a common event across the world. These curricula are mostly well designed and the aims they are intended to achieve are often laudable. However, the attention and energies of policymakers and politicians are focused on the 'what' of desired educational change, neglecting the 'how' (Rogan & Grayson, 2003).

In trying to rescue the implementation problems faced by schools, Rogan and Grayson (2003) proposed a theory based on three constructs, namely, the profile of implementation, capacity to support innovation and support from outside agencies. These constructs share three characteristics:

- They can be measured by means of indicators.
- They are broad enough to encompass a number of related factors.
- They are narrow enough to include one main idea.

The nature of these constructs is given below. The theory is based on the learning environment as unit of analysis, i.e. learners, educators, curriculum and educational resources were considered for the theory. Their focus is based on what happened in the classroom. Classroom observation in the current study on transition was conducted against this background. A brief overview of constructs is given below.

Profile of implementation

This construct attempts to understand and express the extent to which the ideals set out in the curriculum proposal are being put into practice. However, it does assume that new criteria of excellence will emerge from the nature and values of the curriculum. For example, based on the old syllabus in South Africa, excellence of schools was judged primarily on one criterion only, the percentage pass rate on the external matriculation examination. Excellence, as seen from the perspective of C2005, will need to be determined by criteria that are in line with its values and expected outcomes, such as what learners are actually able to do at various points in their schooling (Rogan & Grayson, 2003).

Capacity to support innovation

The construct 'capacity to support innovation' is an attempt to understand and elaborate on the factors that are able to support, or hinder, the implementation of new ideas and practices in a system such as a school (Rogan & Grayson, 2003).

Support from outside agencies

Outside agencies are defined as organisations, including the DoE, that interact with a school in order to implement some kind of change (Rogan & Grayson, 2003). The emergent theory of Rogan and Grayson (2003) is put forward by means of a series of propositions, mostly based on the hypothesized inter-relationships between the three constructs. Outside Support should be organized in a way that ultimately improves the quality of the learning experience for learners. Capacity to innovate should be focused on the extent to which various factors can be considered for providing an enriched and more effective learning experience for learners. If, for example, teachers attend workshops on learner-centred teaching approaches but do not implement them, then the learning experience will not be provided to the learners. In the Profile of Implementation, assessment and use of resources should all be viewed in terms of how well they enrich the learning experience (Rogan & Grayson, 2003).

Since the current study on transition is taking place in a situation where OBE was being implemented, this theory will help put it in context.

2.3.2 Previous studies on transition in science education in South Africa

The DoE (2002(a)) admitted as early as 2002 that there were discontinuities between the curriculum followed by learners in the GET band and grade 10 (the first year of the FET band). Figure 2.1 shows that the highest repetition rate has been in grade 10 from 2001 to 2004. From 1997, OBE was implemented in the GET band but the content based curriculum was followed in the FET band. It was not until 2006 that Curriculum 2005 was replaced by the NCS and introduced in the FET band.

The Department of Education in South Africa commissioned a study on the reasons for the low pass rate in grade 10 in 2003. Reddy et al. (2004) undertook the study and published an extensive list of key findings regarding the period of transition between C2005 and the NCS.

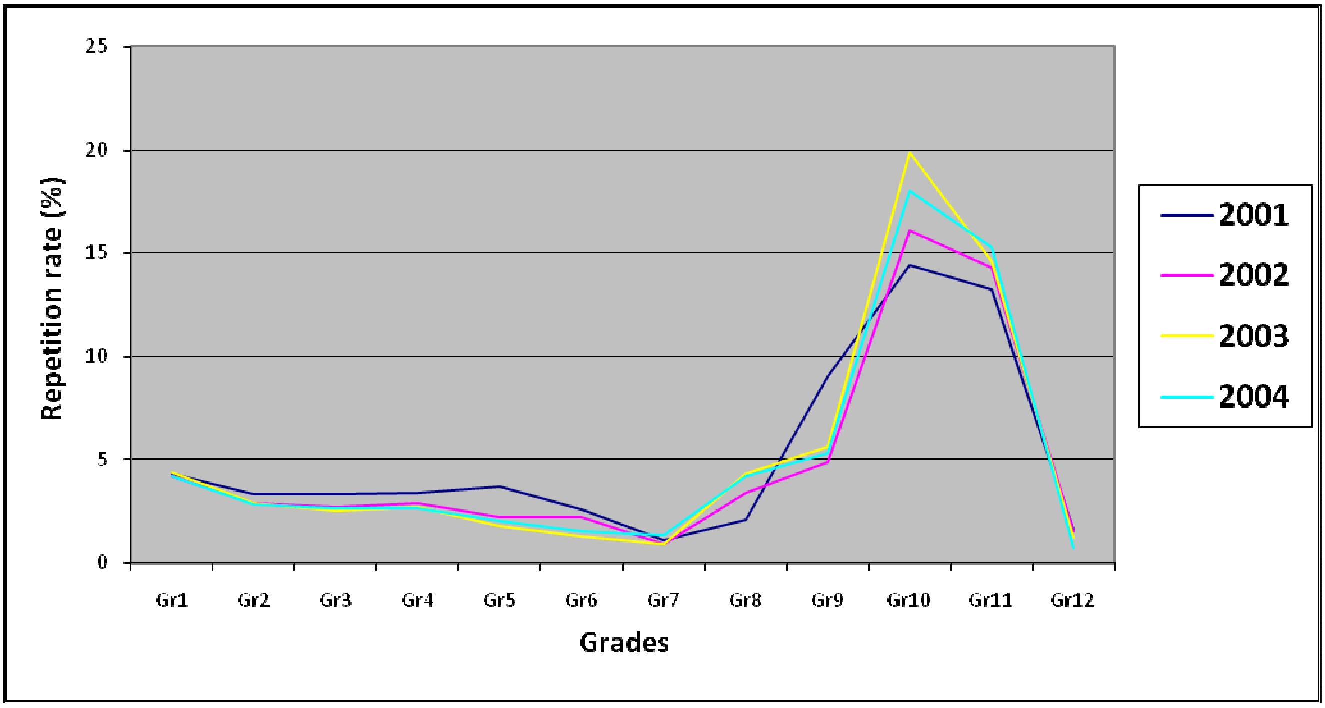


Figure 2.1 The repetition rate from 2001 to 2004. Data source: GDE (Annual Report 2004/2005)

Key Findings

- **Philosophy of the transition phase**

1. There seemed to have been two objectives for the 'transition phase'
   - to infuse the principles of OBE into the FET band and
   - to assist teachers to fill knowledge gaps as a result of moving from an OBE system to a content based system (Résumé of Instructional Programmes in Public Ordinary School, commonly known as NATED 550 (Department of National Education, 1989)).

   They found this to have been over-ambitious and maintained that it would have been less confusing to keep to one aim, viz. filling the knowledge gaps.

2. There seemed to be a tension between the responsibilities of the national DoE and provincial Departments of Education. The DoE gave tight deadlines for the transition and provincial departments felt there was not enough support. Provinces

also felt that the implementation of OBE in Grade 10 was an additional responsibility to their other functions.

3. There was not a strong basis in the educational system of how to manage curriculum change. They noted that South Africa had had many curriculum change processes but did not seem to have a strong body of knowledge of how the process worked.

- **Structures and responsibilities**

4. They found that structural issues between the DoE and provincial departments and within the provinces did not facilitate easy coordination, communication or monitoring. This was evident by, for example, GET and FET directorates not communicating with each other to coordinate the transition process, which involved both directorates. It was sad to note that this pattern existed from the DoE to the classroom level where the grade 9 educator did not communicate with the grade 10 educator in terms of teaching and learning issues. Evidence collected showed that there was no handover of the grade 10 learner by the grade 9 educator in almost all provinces.

- **Enrolments, pass rates and throughputs**

5. Analysis of enrolment rates showed an increase of around 130 000 learners from 2001 to 2003. This was a great expansion of the system and if there had not been a concomitant increase in resources and support, then quality was bound to have decreased.

- **Curriculum**

6. The central hypothesis for the grade 10 results dropping had been the role of OBE. However, the research team's analysis indicated that the learner only experienced 3 years of OBE in his/her schooling career. This seemed to suggest that the reasons for the drop might have been located in the broader issues of educational quality and that required a deeper investigation.

7. There were gaps between the GET OBE curriculum and the FET NATED curriculum and that was to be expected given the difference of the two approaches. There was a great deal of pressure on the grade 10 teacher to fill those gaps, to teach extra 'content' in the same timeframe, and to infuse OBE principles.

8. There was uncertainty about how the grade 12 examination would look in 2005, whether similar to the traditional matriculation examination or based on OBE principles.

- **Cascade model of training**

9. The DoE used a cascade model to implement the decisions for an OBE model in grade 10. This model was found not to be working well. It raised issues of the chain of responsibility and the viability of the cascade model in implementing curriculum change.

10. The cascade model was hastily prepared and not implemented correctly.

11. The research team found no evidence of the DoE consulting provincial departments in terms of the logistical requirements of, and the capacity required to coordinate and monitor the process. This resulted in poor coordination in provinces, lack of proper communication to all levels within the system and no monitoring of the process right from the DoE to the classroom. There was also very little communication to empower the senior management teams ready for the cascade process. This resulted in some principals refusing to release teachers to attend training.

12. The training consisted of a higher amount of generic than specific training and therefore did not give guidance on how teachers could cope in the classroom.

13. They noted that lots of work was done in planning something new, but the same energy did not seem to be involved in seeing through implementation. They argued

that ultimately even the best policies would have succeeded or failed depending on the attention given to the implementation strategies.

14. There seemed to be a single package designed for different situations. For example, in KwaZulu Natal (KZN), the rural dynamic meant a different model of training ought to have been planned.

In the light of the above findings, the research team made recommendations, some of which are listed below (Reddy et al., 2004):

Recommendations

1. It is important that there is an alignment between the grades 9 and 10 assessment systems so as to not disadvantage the learners.

2. Teachers in the FET phase should concentrate more on filling the knowledge gaps than infusing the principles of OBE in the curriculum.

3. Since 1994, South Africa has been involved in curriculum changes to Curriculum 2005, followed by the RNCS and NCS. For the transitions between curricula, the cascade model of training has, however, been problematic. This was further compounded in the rushed and under-resourced manner in which the training was done. The issues of managing curriculum change in a large system are very complex and complicated and require much planning and many resources. There should be greater thought, planning and resources given to the implementation phase.

4. As the country moved towards the process of implementation of the NCS in 2006 for the FET system, the lessons of the implementation models used for the transition phase (and possibly the RNCS) should be examined and a more thorough model developed.

5. Ensure that the training packages are differentiated to meet the different contextual realities. A “one size fits all” model does not work.

6. In training for the future FET curriculum, ensure that the training consists more of what would be relevant to teachers in the classroom than broad, generic principles.

7. There should be monitoring in the schools to see what happens in schools.

8. The issues of implementation are key to the success in effecting curriculum change. Therefore there must be many more resources for this aspect of the curriculum change process.

2.3.3 Transition within transition

The following unique set-up in education in South Africa must also be taken note of when studying transitions:

There are different types of institutions. These are pre-primary, primary, intermediate/middle, secondary and university. With the introduction of the new curriculum (OBE), the following phases were also introduced:

- Early Childhood Development (from birth to grade 0)
- Foundation phase: grade 1 – grade 3
- Intermediate phase: grade 4 – grade 6
- Senior phase: grade 7 – grade 9
- FET phase: grade 10 – grade 12

Table 2.1 shows the number of schools in Gauteng offering particular ranges of grades. Some of the phases overlap into different types of institutions. For example, most primary schools offer tuition up to grade 7, which is the first year of the senior phase (refer to Table 2.1). When a learner proceeds to grade 8 to continue with the senior phase, s/he has to go to a different school with a different culture of teaching and learning. This exposes the learner to the dangers that Braund and Hames (2005) referred to, namely:

> *A new, larger and more challenging environment, new friendship groupings, new teachers and new rules that will make demands on the learner as well as the fear of the unknown after transfer to a new school.*

Table 2.1 Schools in the Gauteng province according to lowest and highest grade (2006)

	Public ordinary schooling – schools according to lowest and highest grade												
	Foundation Phase			Intermediate Phase			Senior Phase			Further Education and Training phase			
	Gr 1	Gr 2	Gr 3	Gr 4	Gr 5	Gr 6	Gr 7	Gr 8	Gr 9	Gr 10	Gr 11	Gr 12	Total
Gr 1			8	62	5	66	1024	41	24	1		33	1264
Gr 2								3					3
Gr 3							1						1
Gr 4						1	5		1				7
Gr 5							43	1	1				45
Gr 6													1
Gr 7									25				28
Gr 8									9	4	2	440	455
Gr 9													4
Gr10													20
Total			8	62	5	67	1073	45	60	5	2	501	1828

Note: The grades (Gr) in the left-hand column indicate lowest grade available in each school, and the grades (Gr) along the top row indicate the highest grade. Adapted from the Annual Survey of Schools (2006) in the Annual Performance Plan 2007/08 to 2009/10 (GDE, 2008). It must be noted, however, that by some mistake, the numbers under the grade 12 column in Table 2.1 do not add up to 501 – and this is so from the source.

The importance of Table 2.1 is that it helps with the understanding of the breakdown of grades within phases across the schools of Gauteng. From the table it can be seen that the majority (1073 out of 1828) of schools in the Gauteng province offer tuition up to grade 7, the first year of the senior phase, and that only 51 schools out of 1 828 offer the full complement of grades in the senior phase (grades 7 – 9). Most learners, therefore, have to be transferred from one school to another within the senior phase.

Throughout the senior phase, learners were taught according to C2005, where content was left almost entirely to the discretion of the teacher and the school while the grade 10 – 12 curriculum was content based. Up to 2005, the old content based curriculum taken over from the previous dispensation was still in place in the FET. When the NCS was introduced in the FET in 2006, content was again specified, this time by the Assessment Standards in Physical Science which gave an indication of content. Learning Area statements specified content that needed to be included and outcomes encouraged local applications of content. Consequently learners who graduated from the outcomes based grade 9 in 2005 had to enrol for grade 10 Physical Science, in which content that had to be included was specified. The senior phase learner in South Africa was therefore faced with double transition problems: those within the senior phase and those across the senior phase/FET interface. He or she had to cross the border from grade 7 at primary school to grade 8 at a new secondary school where s/he was to complete the senior phase and then proceed to a new phase, namely FET, in grade 10.

2.4 THEORETICAL FRAMEWORK

The theoretical framework that was used to understand the issues in this study was adapted from the model developed by Rollnick et al. (1998) that provides a basis for investigating gaps in education.

There are studies that link transition problems to gaps between consecutive phases in education. For example, the transition from high school to university may appear so severe that a substantial proportion of students fail to cope with their first-year chemistry courses (Bradley, Brand & Langley, 1985). This has been attributed to a gap between high school and university chemistry (Cantrell, Kouwenhoven, Mokoena & Thijs, (eds), 1993). Grayson (1996) states that it is common to speak of a gap between high school and university and that this gap exists for all students coming largely from the highly authoritarian and disciplinarian type of schooling. It is therefore necessary to build into the theoretical framework the conceptualisation of the gap in the levels of education.

Crowther et al. (1995, p. 486) define a gap as “an opening or a break in something or between two things or a lack of something that is needed”. Grayson (1996) refers to the gap between high school and university as “a discontinuity between the attitudes to learning, amount of work, intellectual environment and other factors encountered” (Grayson, 1996, p. 993). Rollnick et al. (1998) developed a model providing a basis for investigating gaps holistically. The current study used the word ‘gap’ as conceptualised in the adapted model by Rollnick et al. (1998), as shown in Figure 2.2.

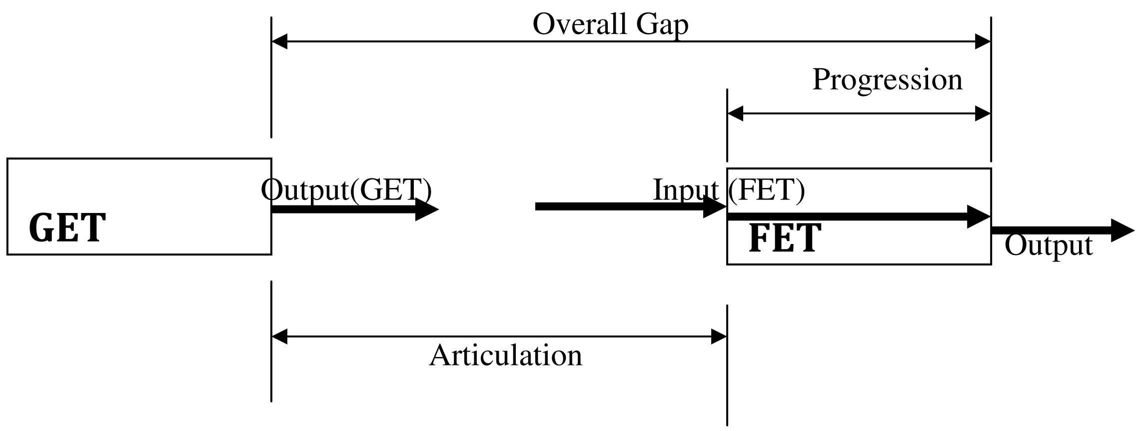


Fig. 2.2 Aspects of a gap adapted from Rollnick et al., 1998

The gap is being identified on the basis of a mismatch between the output of one level and the input of the next level in the education system, namely, GET and FET as shown in Fig.2.2. This is, however, blurred by two possible contributing aspects that may exist, namely, a momentary and a longitudinal aspect. A gap can be characterised by what happens at the interface between the two levels: between the end of one stage (grade 9) and the beginning of the next stage (grade 10). This is referred to as the *articulation*. A gap may also be characterised by what happens within the latter educational stage (FET), referred to as the *progression* or lack thereof during the stage. The two aspects, articulation and progression combined, will be referred to as the *overall* gap. The presumed gap will therefore be explored by the extent to which grade 9 is aligned with grade 10, and then by the nature of the throughput during the FET phase.

The first research question aimed to describe the characteristics of the transition in an objective way. At the articulation of the gap, I investigated whether the knowledge output of the GET phase matches the knowledge input required for the FET phase. Furthermore, I investigated differences in the GET and FET curricula, assessment practices and teaching strategies that could perpetuate throughout the progression of the FET.

The second research question aimed to explore the transitional experiences from the learners' perspective. Changing interest in science at the articulation as well as during the progression of the gap were investigated, while performance, conceptual understanding and relationships with teachers were explored throughout the progression of the gap to capture a rich, detailed image of learner's experiences of the transition.

The third research question explored learners' strategies to deal with the transition throughout the progression of the gap. Performance, epistemological orientation, problem solving skills and career choices were explored as indicators of learners' coping.

It is within this framework of a gap that I explored the transition from Natural Science in the GET phase to Physical Science in the FET phase at the time of a changing curriculum. Important, the existence of the overall gap was presumed. I did not try to prove the existence of the gap, but rather to describe the characteristics of the gap, the learners' experiences of the gap and their strategies to cope with the demands of the gap. The theoretical framework provided a structure against which I explored how the characteristics of the transition at the articulation and progression throughout the gap contributed to the learners' experiences and how they managed these experiences throughout the progression of the gap.

2.5 WAY FORWARD

The focus of this study is learner experiences in the transition from the General Education and Training band to the Further Education and Training band in the sciences. So a longitudinal study was conducted from the learners' perspective. In trying to understand the learner experiences, it was important not only to include their perspective, but also their learning environment. Therefore, documentation and classroom observation were used to provide the background to understand learners' experiences. To explore learners' experiences, various instruments were employed to assess performance, conceptual understanding, knowledge of the Nature of Science, and interest in science.

2.6 CHAPTER SUMMARY

This chapter reviewed literature on transitions in education, transitional problems and suggested solutions. International studies on transition in science were discussed from the perspective of the curriculum, the teachers, the learners and attitudes towards studies. A number of recommendations from previous studies were discussed and a critique of some of them was given. Motivation for studying transition in science education was given, that is conflicting aims to teaching science, the nature of science and different epistemological beliefs. I also discussed an emerging theory on the implementation of the Natural Science learning area of Curriculum 2005 and a study on the high grade 10 failure rate. Finally, a model on gaps in education developed by Rollnick et al. (1998) was discussed to provide a theoretical framework for the study.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This is a four-year longitudinal study that follows a mixed method approach, in which qualitative methods are being complemented by quantitative ones. The chapter opens with a description of the sample and research design, followed by the instruments and methods of data collection and data analysis, with details of steps taken to ensure validity and reliability, and ethical considerations.

3.2 SAMPLE

Two neighbouring township schools were initially involved in the study. Both schools produced good matriculation results: school A had an average pass rate of 99% while school B had a 88% pass rate over the previous 5 years (2000-2004). These schools were purposively selected for good performance and convenient location for accessibility. All the grade 9 learners, totalling 417, participated in the data collection for the GET phase during 2005. For the FET phase, school A was selected for data collection in order to report on a best case scenario. This school was given an award in 2005, by the Member of the Executive Council responsible for Education in the Gauteng Province, for being the best school from a department of education to have previously served Blacks only under apartheid. In school A, 61 learners chose to continue with Physical Science in grade 10. This group of 61 learners from school A was used for data collection in the FET phase. Attrition further reduced the FET group to 40 learners by the time they reached grade 12.

3.3 RESEARCH DESIGN

According to Mouton (2001), case studies are usually qualitative in nature and aim to provide an in-depth description of a small number of cases. Unlike the experimenter who manipulates variables to determine their causal significance, or the surveyor who asks standardised questions of large representative samples of individuals, the case study researcher typically observes the characteristics of an individual unit, e.g. a class or a school (Cohen & Manion, 1994). A case study cannot rely on a single data collection method but requires multiple sources of evidence (Yin, 2003). As this was a case study of learners in transition from the GET band to the FET band, various instruments, qualitative as well as quantitative, were used. Data sources included curriculum documents, the 2005 grade 9 national examination (CTA), lesson observations, an interest questionnaire, a questionnaire on the Nature of Science, a chemistry diagnostic test, the 2007 grade 11 examination results, and interviews.

The research design is diagrammatically represented in Figure 3.1. It adopted a mixed quantitative and qualitative approach to follow closely the learners' experiences and reflections on their experiences during the critical period of transition. A group of learners were followed from grade 9 into the FET band. Qualitative and quantitative data were collected from the cohort and from eight individual learners. It was intended that the interviews with individual learners would provide the fine-grained detail necessary to describe and interpret the changes associated with transition, while the group data would allow these interpretations to be placed in context.

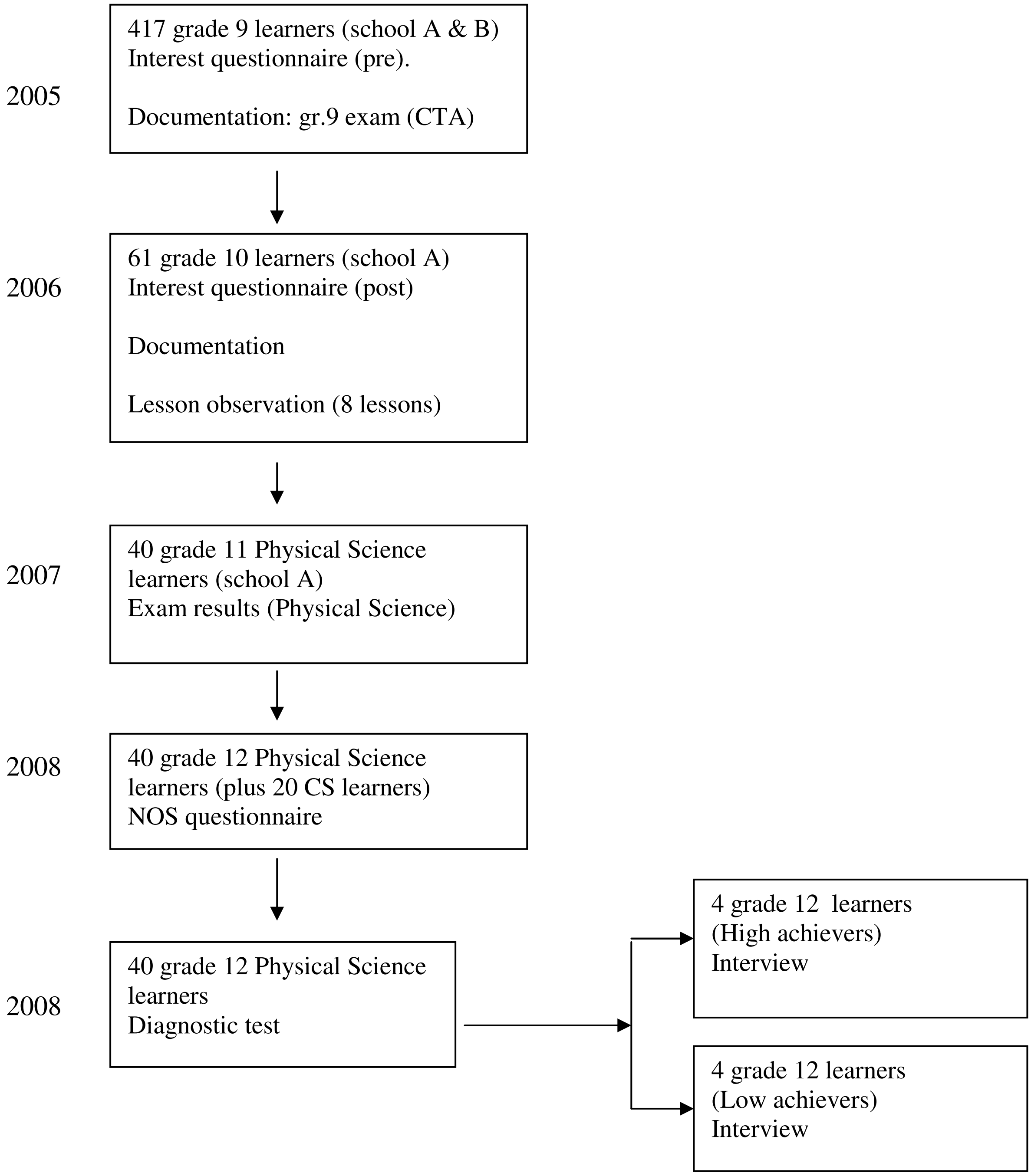


Figure 3.1 A diagrammatic representation of the research design

3.4 INSTRUMENTS AND DATA COLLECTION

The data collection methods used in this study comprised of documentation analysis, an interest survey, classroom observation, a diagnostic test, a questionnaire on the Nature of Science (NOS), interviews and the grade 11 examination results.

3.4.1 Documentation

Document analysis was employed to explore the matching between the GET and FET phases regarding content as well as assessment .This helped to explain how the transition from Natural Science in the GET phase to Physical Science in the FET phase can be characterized in order to answer research question 1.

The Policy Document on the Senior Phase (DoE, 1997), the national GET examination papers of 2005 (DoE, 2005b), and the Revised National Curriculum Statement (DoE, 2002b) were scrutinized to determine whether the learners were exposed to content needed for grade 10 Physical Science. As content was not prescribed by C2005, the grade 9 national examination, called the Common Tasks for Assessment (CTA), was analyzed to assess to what extent concepts required for FET science were examined (DoE, 2002a).

The National Policy on Assessment and Qualifications for schools (DoE, 2006b) shed light on the assessment policy in the senior phase. This enabled me to compare the way assessment was carried out in the GET and FET phases.

According to a study in Western Australia (Chadbourne, 1995), which used documentation as data collection method, the high school curriculum was dominated by university entrance requirements. Learners worked from textbooks and covered the prescribed content of science units that had a long list of very specific objectives explicitly linked to student assessment (Rennie & Parker, 1993). In contrast, the primary syllabus contained four pages of general concepts to be covered during the eight years of pre-primary and primary school and allowed the educator to be flexible as specific content was not prescribed for primary science. I found this to be very similar to the current educational set-up in South Africa and therefore I used official documents to answer research question 1.

3.4.2 Interest survey

Studies worldwide show that positive attitudes towards science decrease throughout the school years, with the most dramatic change occurring during the transition from primary phase to the secondary phase (Schoon, Ross & Martin, 2007; Linn & Hyde, 1989). Therefore I administered an interest questionnaire to explore how learners' interest in Physical Science change during the transition from GET to FET. Changing interest was used as an indicator of learner's experiences of the transition, to shed light on research question 2. Also, a low level of interest in Physical Science during the FET phase could result in career choices avoiding Physical Science (Speeering and Rennie, 1996), which would be a way to manage a difficult transition. Therefore the interest questionnaire could also provide answers to research question 3.

According to Gay and Airisian (2003), typical survey studies are concerned with assessing attitudes, opinions, preferences, practices and procedures, and collections of survey data is usually by questionnaires, interviews, telephone or observation. The questionnaire used in this study, given in Appendix A, was modified from the 'Interest Questionnaire for the Natural Science Field of Study (IQNSFS) designed by Swanepoel (1986). In order to validate the instrument, I used the group of 417 grade 9 learners from the two neighboring schools A and B. According to Maree (2003), the size of the sample has to be between five and ten times the number of items in the questionnaire if the researcher wishes to carry out item analysis. The test consisted of 84 items, and a total of 417 learners participated, meeting the requirement sufficiently.

The questionnaire was firstly used to compare learners' interest in Physical Science, Life Science, Mathematics and Computer Science for the original group of 417 learners. These subjects represent one of the learning fields from which learners who graduate from grade 9 have to choose subject combinations for grade 10. The questionnaire consisted of 84 items, 21 questions from each subject. (Refer to Table 3.1). Each item involved an activity related to one of the 4 subjects. Learners had to indicate on a scale of 0 to 3 how much they would like to do each activity.

When the learners reached grade 10, the questionnaire was repeated to explore the trend in interest as they moved from one phase to another. The results of the 61 learners who continued with Physical Science in grade 10 were compared to the results of the same group when they were in grade 9 to ensure that the comparison was valid.

Table 3.1: The distribution of questions in the IQNSFS according to subject.

SUBJECT							
Physical Sciences (PS)		Life Sciences (LS)		Mathematical Sciences (MS)		Computer Sciences (CS)	
Item no.	V no.	Item no.	V no.	Item no.	V no.	Item no.	V no.
1	v3	6	v8	2	v4	3	v5
4	v6	10	v12	7	v9	8	v10
5	v7	11	v13	9	v11	13	v15
14	v16	15	v17	12	v14	16	v18
19	v21	17	v19	18	v20	21	v23
20	v22	22	v24	25	v27	24	v26
23	v25	26	v28	28	v30	27	v29
29	v31	33	v35	31	v33	30	v32
32	v34	38	v40	34	v36	36	v38
35	v37	41	v43	42	v44	39	v41
37	v39	44	v46	47	v49	40	v42
43	v45	45	v47	50	v52	46	v48
48	v50	53	v55	51	v53	49	v51
52	v54	55	v57	56	v58	54	v56
59	v61	62	v64	58	v60	57	v59
63	v65	67	v69	61	v63	60	v62
69	v71	71	v73	66	v68	64	v66
70	v72	74	v76	72	v74	65	v67
77	v79	76	v78	75	v77	68	v70
81	v83	80	v82	78	v80	73	v75
84	v86	83	v85	82	v84	79	v81

3.4.3 Observation

Classroom observations were carried out to explore the teaching practises of the grade 10 teacher and to observe learners' behaviour in class. These observations could help answer all three research questions. Firstly, some answers to question 1 can be found by describing the transition in terms of teaching and learning situation. Answers to questions 2 and 3 can also be found as learners' behaviour would be an indication of how they experience and negotiate the transition.

In observational techniques, the current status of a phenomenon is determined not by asking but by observing (Gay & Airisian, 2003). The advantages of observation as a qualitative data collection type are that the researcher has a first-hand experience with participants, can record information as it is revealed and can notice unusual aspects (Creswell, 2003). Observations can take a number of forms in qualitative research, depending on the involvement of the observer. The observer can be a participant observer, who engages fully in the activities under study but is known to the participants as a researcher. Alternatively, an observer may be a non-participant observer of the activities of the group being studied, that is, one who watches but does not participate (Gay & Airisian, 2003). The advantages of participant observation include the ability to gain insights and develop relationships with the participants. The disadvantages of participant observation are, however, that the researcher may lose objectivity and become emotionally involved with participants, and may also have difficulty participating and taking detailed field notes at the same time. Non-participant observers, on the other hand, are less intrusive and less likely to become emotionally involved with participants (Gay & Airisian, 2003). It is for this reason that I used non-participative observation in the classroom in an attempt to answer the following: What teaching strategy is used? What is the nature of learner engagement in the classroom? How do learners respond to the teacher's directives and questioning style?

Speering and Rennie (1996) also conducted a longitudinal study that mapped the transition between primary and secondary school in Western Australia from the learners' point of view. They focused on the subject of science and used both quantitative and qualitative methods. They made lesson observations that revealed a wide range of teaching strategies. They noted that in primary science an emphasis was placed on hands-on activities and co-operative learning in small groups. In secondary science students were disappointed at the lack of hands-on activities, too much emphasis on "chalk and talk", the amount of note-taking and listening to lectures.

Teachers' actions, assessment and use of resources should all be viewed in terms of how well they enrich the learning experience (Rogan & Grayson, 2003). Learning in class is a dynamic process in which there is interaction of learners, educators and context, with content being the main component of context (Hewson, 1988). It is in this context that I used classroom observation to find out what teaching style is being used by the teacher and what learning strategy is used by learners to overcome the transition problems in the FET class. The classroom observation instrument is adapted from the Integrated Quality Management System (IQMS) instrument from the Education Labour Relations Council (ELRC, 2003) (given in Appendix E).

Appendix F is an exemplar of a grade 10 Physical Science Lesson plan the teacher should have followed, Appendix G is a hand-out for the grade 10 Physical Science according to the NCS and Appendix H and I are both transcripts of Physical Science Lessons that were observed.

3.4.4 The paper and pencil diagnostic test

Learners' conceptual understanding in the FET phase could help us to understand how they experienced the transition, thereby providing answers to research question 2. Also, strategies and approaches when dealing with questions that require conceptual understanding could indicate how they managed the transition, thus providing answers to research question 3. Therefore, a diagnostic test was administered to assess conceptual understanding and problem solving skills.

In setting a diagnostic test I had to choose between true-false questions and multiple-choice questions by considering their advantages and disadvantages. True-false questions are advantageous because a great number of questions can be answered in a short time, permitting a broad sampling of knowledge. Answers to the questions can be quickly scored, particularly if a key is used. Furthermore, the true-false test is an excellent tool to use for pretesting to determine the status of learners at the beginning of a unit. (Collette & Chiappetta, 1984). The true-false statements were not used, however, because they usually have poor validity and low reliability, and the probability of guessing the right response is 50%, which gives the poor or unprepared student an excellent chance of providing the correct answer. Furthermore, predictions and comparisons are difficult to test because these types of learning outcomes are not easily expressed in statements that are either right or wrong (Collette & Chiappetta, 1984).

Multiple-choice questions are not easy to construct, it being difficult to write plausible distracters, and just as difficult to find four or five closely related options, only one of which is correct. In addition, ambiguity is usually a problem (Collette and Chiappetta, 1984). However, the disadvantages are outweighed by the advantages, particularly when one compares them to true-false statements. I prefer multiple-choice questions to true-false statements because they have a higher reliability than true-false items and are easy to score; the probability of guessing is lower. Furthermore, they are not only useful for testing factual information but are particularly suitable for testing higher levels of understanding, e.g. analysis, evaluation and synthesis (Collette & Chiappetta, 1984). Prepared items are also available from research literature.

The test was administered during the grade 12 year to the remaining 40 learners who chose Physical Science as a subject in gr 10. The test was adapted from Novick and Menis (1976), and is given in Appendix D. For each item, learners had to explain their chosen answer and indicate a level of confidence in their answers. The test consisted of two multiple choice items, one on the mole concept and one on Avogadro's hypothesis. The content areas of the test were based on identified problem areas from my experience as a Physical Science teacher, a chief examination marker, a Physical Science advisor, a co-author of Natural Science textbooks and a grade 12 Physical Science Chemistry examiner for the Gauteng Department of Education.

The data gathered from the diagnostic test were also used together with results from the NOS questionnaire in an attempt to understand if and how learners' scientific epistemological beliefs related to their conceptual understanding and problem solving strategies, which could further illuminate research questions 2 and 3.

Responses to the diagnostic test were further explored during interviews with eight individuals.

3.4.5 The NOS questionnaire

Understanding the Nature of Science (NOS) has been regarded as one of the basic requirements for scientific literacy (Lin & Chiu, 2004). It was found that student views of science were significantly related to their knowledge integration and learning orientation methods (Tsai, 1998).
This implies that learners' scientific epistemological beliefs may be related to their coping with science. Therefore, I administered a questionnaire to explore learners' understanding of the Nature of Science, as results could provide answers to research question 3. I hoped to relate learners' epistemological inclinations to their strategies and approaches for negotiating the transition.

The Nature of Science is a fundamental issue for philosophers of science (Klee, 1997). Studies by philosophers, scientists and educationists attempting to investigate the philosophical underpinnings of science in relation to teaching often observe poor understanding of the NOS amongst educators and learners (Linneman, Lynch, Kurup, Webb and Bantwini, 2003). Philosophers have made spirited attempts to provide recommendations in the form of national guidelines (McComas & Olson, 1998).

The questionnaire, consisting of 48 items on a five-point Likert scale, is given in Appendix C. The items of the NOS questionnaire were derived from the Nature of Scientific Knowledge Scale (NSKS) (Rubba & Anderson, 1978). The subscales are amoral, creative, developmental, parsimonious, testable and unified. These subscales are described in Table 3.2. Each subscale was composed of eight items, four positive and four negative as indicated in Table 3.3.

One problem with questionnaires is that if a question is incorrectly understood or the answer is incomplete, nothing can be done about it, unlike an interview where any misunderstanding could be cleared. Emotions and sentiments are difficult to express in writing. Furthermore, many subjects fail to answer questions completely honestly, instead giving the researcher the answer they think he or she wants to hear (du Toit, 1992). However, according to du Toit (1992), questionnaires are probably the most commonly used means of collecting data. It is an economical way of collecting information for both researcher and subject, since it saves time, input and costs. Furthermore, if carefully and correctly compiled, the researcher can ask anyone to administer questionnaires on his/her behalf, and it can help subjects by focusing their attention on significant items. Greater uniformity is more likely to be achieved in the answers given if they are in writing and accompanied by clear instructions (du Toit, 1992).

Table 3.2 Model of Scientific Knowledge (Rubba & Anderson, 1978)

NSKS subscale	Description
Amoral	Scientific knowledge provides man with many capabilities, but does not instruct him on how to use them. Moral judgements can be passed only on man's application of scientific knowledge, not on the knowledge itself.
Creative	Scientific knowledge is a product of the human intellect. Its invention requires as much creative imagination as does the work of an artist, a poet, or a composer. Scientific knowledge embodies the creative essence of the scientific inquiry process.
Developmental	Scientific knowledge is never "proven" in an absolute and final sense. It changes over time. The justification process limits scientific knowledge as probable. Beliefs which appear to be good ones at one time may be appraised differently when more evidence is at hand. Previously accepted beliefs should be judged in their historical context.
Parsimonious	Scientific knowledge tends toward simplicity, but not to the disdain of complexity. It is comprehensive as opposed to specific. There is a continuous effort in science to develop a minimum number of concepts to explain the greatest possible number of observations.
Testable	Scientific knowledge is capable of public empirical test. Its validity is established through repeated testing against accepted observations. Consistency amongst test results is a necessary, but not a sufficient condition for the validity of scientific knowledge.
United	Scientific knowledge is born out of an effort to understand the unity of nature. The knowledge produced by the various specialised sciences contribute to a network of laws, theories and concepts. This systemized body gives science its explanatory and predictive power.

Speering and Rennie (1996) used a questionnaire in their study of learners' perceptions about science, so as to select case study learners. It consisted mostly of open-ended questions about the learners' experiences of primary science, its perceived relevance, the educators' relationships with learners, gender issues, achievement and their expectations of secondary science.

The NOS questionnaire was administered to the 40 Physical Science learners who progressed to the grade 12 year. I also administered the test to 20 Commercial Science learners who were not taking Physical Science. I intended to establish whether the learners taking science had a different understanding of the Nature of Science, as students' views of science are significantly related to their knowledge integration and learning orientation methods (Songer & Linn, 1991; Tsai, 1998). Therefore, the science learners' performance on the NOS questionnaire would be related to their knowledge integration which might illuminate research questions 2 and 3 on experiences and coping with the transition.

3.4.6 The Grade 11 Physical Science examinations

The grade 11 Physical Science examinations were not set by me or by the teacher. They were common national examinations set by the Department of Education. The examination was therefore regarded as a litmus test of learners' progression or lack thereof through the FET phase.

Performance as measured by this examination was used as an indicator of learners' experiences of the transition. Furthermore, performance in Physical Science during the FET phase was also regarded as an indication of coping with the transition. Therefore, the examination results could shed light on research questions 2 and 3.

The examination results were also used in conjunction with the results of the Interest Questionnaire and the results of the NOS questionnaire to explore whether interest in Physical Science and epistemological inclination were related to performance. This could be useful to triangulate results.

3.4.7 Interviews

Recognizing the limitations of paper and pencil tests and questionnaires, interviews were used to collect rich data on the transition from a few individuals. Pope and Gilbert (1983) asserted that successful understanding between people "depends not so much on the commonality of the construct systems but on the extent to which people can understand the construct system of the other" (p. 197). This provides ample motivation for the interview to be used as a supplement to the questionnaire and the diagnostic test in helping to understand the thinking of the student to provide answers to research questions 2 and 3.

The interviews were conducted just after the diagnostic test that had been written. Some of the interview questions were based on the diagnostic test in order to clarify learners' answers. The interviews also probed other aspects relating to transition. The aim was to get a balanced mix of reactions to questions on:

- Attitude towards science during transition
- Career choice
- Favourite subject
- Teacher-student relationships over the period of transition
- Expectations of teaching strategies ahead of transition
- Description of transition in their own words

Interviewers try to make sense of the cognitive processes that accompany learners' responses. Confrey (1990) argues that if one wants to know more about knowledge, one should ask the people who claim to know and the student who comes to know. Research interviews are usually divided into two broad categories, namely structured and unstructured. In a structured interview (Behr, 1983) the interviewer usually takes the lead. Definite guidelines are followed here because the interviewer requires specific information. This implies predetermined procedures. The interviewer draws up an interview schedule in which the following are described:

- the course of the interview
- the way in which instructions and questions are to be worded
- the way in which answers will be processed

In an unstructured interview, the interviewer usually does not take the lead, though according to a predetermined protocol it need not be a random or unfocussed process. According to Traxler and North (1966), the art of unstructured interviewing is that the questions should appear to arise spontaneously from the conversation. According to Jacobs and Vrey (1982), the unstructured interviewer must endeavour to listen perceptively to what the subject is saying. This means hearing what the subject is saying, not just what the interviewer wishes to hear. If the interviewer hears what s/he wishes to hear, s/he is working in terms of a personal internal frame of reference. If the interviewer listens in terms of the external frame of reference, s/he will be in a position to listen not only to the spoken words, but also to what is left unsaid. The interviewer should furthermore note the tone of voice and intonation. According to Mackay (1973), open questions should be asked in an unstructured interview. Questions should neither imply an answer, subtly reveal the attitude of the interviewer nor pass judgement.

In this study the interviews were mainly semi-structured, in which follow-up questions flowed from the response of the subject, thus combining the most useful aspects of both structured and semi-structured interviews (McMillan & Schumacher, 2006). The interviews were conducted with eight learners who were taking Physical Science. The learners were purposively selected for performance: the four highest scoring learners and the four lowest scoring learners were selected.

Semi-structured interviews were the main qualitative data source in the study of students' perceptions about science conducted by Speering and Rennie (1996). Speering and Rennie (1996), reported on a longitudinal study that mapped, from the students' point of view, the transition between primary and secondary school in Western Australia. In their interviews with the subjects, they asked them questions based on: school change, attitude to science, teaching strategies, teacher-student relationship, favourite subject, career choice. The interview questions in the current study were also categorised in the same manner. Furthermore, the subjects were asked to review their answers to the conceptual problem-solving diagnostic test. In addition, key terms such as GET and FET were explained to the subjects before the interview.

The interviews were audio-tape recorded and transcribed verbatim, given in Appendix J. According to Behr (1983), a tape-recorder is a convenient method of keeping a detailed and accurate record of an unstructured interview. The advantage here is that nuances such as tone of voice, hesitations and emotional responses are not lost. The interviewer should put the interviewee at ease by explaining the purpose of the recording and how the information will be dealt with.

3.5 DATA ANALYSIS

Once data had been collected, the analysis took place. Documents, classroom observations, questionnaires (both the IQNSFS and the NOS survey), the diagnostic test and interviews were analysed. The results of the grade 11 examination were primarily used as an external measure of learner achievement, to be correlated with interest and epistemological inclination.

3.5.1 Document analysis

Analysis of the curriculum documents was made for scope and depth of coverage of content. The topics tested in the CTA for the grade 9 Natural Science were matched with those prescribed for the NCS.

3.5.2 Classroom observation

Non-participative observation of a natural setting was carried out to find out about the nature of learner engagement in the classroom. A total of eight grade 10 lessons, consisting of four sets of twin lessons taught to two classes, were observed and coded numerically in the chronological order in which they were observed. This was done for easy reference. Rennie (1990) and Kelly (1995) observed science lessons without using observation schedules, instead creating their own categories from the field notes that they had taken. These were then used to focus their descriptions of the observed lessons. The categories used in this study for focus on the description of the lessons are adapted from Manyatsi (1996), as general features of the lessons, questioning style of the teacher, directives and/or statements made by the teacher and the nature of learner engagement.

3.5.3 Questionnaires and interviews

The IQNSFS questionnaire

According to the NCS, learners who graduate from grade 9 have to choose subject combinations from some of the eight learning fields in grade 10. One such learning field is the Physical, Mathematical, Life and Computer sciences. The Interest Questionnaire (IQNSFS) consists of 84 questions from the Physical, Mathematical, Life and Computer sciences, with 21 questions from each subject. (Appendix A).

Arithmetic means, standard deviations and median of the distribution of scores formed the basis of item analysis to determine the level of interest in the different subjects. Firstly, the reliability of the questionnaire was determined. For each subject, items were left out one by one while calculating the correlation of the scores of the remaining items to assess whether specific items fitted with the rest.

When the learners were in grade 9, the test was used to compare interests in the four subjects, and also to compare boys and girls. The questionnaire was repeated in grade 10, with the 61 learners who continued Physical Science. The performance of the grade 10 group was compared to the performance of the same group of 61 learners when they were in grade 9. In this way, changes of interest in science at the articulation of the transition could be determined to assess learners' experiences of the transition.

Scores on the interest questionnaire were also correlated to the grade 11 examination scores to probe a possible link between interest and achievement during the transition.

The NOS questionnaire

Table 3.3 shows how the questionnaire was scored. Positive Item V-numbers were scored from 1 to 5, i.e. "strongly disagree" to "strongly agree", whereas the Negative Item V-numbers were scored in reverse. Table 3.4 indicates which numbers had to be scored in reverse.

Table 3.3 NSKS Item Point Value Assignments

Response	Positive Item Value	Negative Item Value
Strongly Agree	5	1
Agree	4	2
Neutral	3	3
Disagree	2	4
Strongly Disagree	1	5

In scoring the NSKS, the point value assignments shown in Table 3.3 were made. Subscale scores were calculated by adding the appropriate four positive and four negative items (refer to Table 3.4). By summing up these subscale scores, an NSKS score is calculated. A maximum score of 40 points for each subscale and 240 points for the entire NSKS score is possible. Table 3.4 also classifies the items according to the subscales in Table 3.2.

The learners were also categorized as post-positivist-oriented or empiricist-aligned, based on their score on the NOS survey. The responses of the two belief groups (post-positivist and empiricist) to the diagnostic test and their marks in the examinations were then compared to establish which group coped better with the challenges of transition.

Table 3.4 NSKS Item-to-subscale key

NSKS Subscale	Positive Item **V**-numbers	Negative Item **V**-numbers
Amoral	6, 7, 10, 50	9, 20, 23, 38
Creative	19, 22, 30, 34	3, 25, 36, 43
Developmental	18, 28, 39, 44	27, 29, 33, 45
Parsimonious	4, 8, 31, 48	16, 17, 41, 42
Testable	14, 24, 40, 47	11, 13, 15, 35
Unified	5, 32, 37, 49	12, 21, 26, 46

Interviews

To understand their strategies of coping with the transition, eight of the Physical Science learners in grade 12 were selected to participate in follow-up semi-structured interviews. They were labelled as high academic achievers or low academic achievers based on their grade 11 Physical Science examination results. The 4 highest achievers and 4 lowest achievers were selected for interviews.

3.6 VALIDITY AND RELIABILITY

Researchers use several strategies to check on and enhance a study's validity. According to Cohen and Manion (1994), inferences about validity are made too often on the basis of face validity, that is, whether the questions appear to measure what they claim to measure. Reliability, on the other hand, is the extent to which findings can be replicated or reproduced by another inquirer, while objectivity is the extent to which findings are free from bias (Denzin & Lincoln, 1994). Reliability is not prized for its own sake, but as a pre-condition for validity, as an unreliable measure cannot be valid (Lincoln & Guba, 1985). I used a combination of the following strategies in order to reduce researcher bias and improve the reliability and validity of the data collected:

- Used a range of instruments to allow triangulation.
- Included a similar neighbouring school to validate the interest questionnaire with a sufficiently large sample of grade 9 learners.
- Used verbatim accounts of interviews or observations by collecting and recording data with tape-recordings or detailed field notes, including quotes.
- Agreed with the participants not to make prior appointment for a particular lesson but instead show up unannounced. This was to avoid having lessons specially prepared for the classroom observation. If participants were absent on any particular day, particularly the teacher, another visit would be arranged.
- Recorded my own reflections, concerns and uncertainties during the study and referred to them when examining the data collected.
- Chose options with higher reliability, e.g. multiple choice rather than true false when it came to pen-and-paper tests.
- Determined the Cronbach reliability coefficient where applicable.

3.7 TRIANGULATION

In triangulation, researchers make use of multiple and different methods to provide corroborating evidence (Miles & Huberman, 1994; Erlandson, Harris, Skipper & Allen,1993; Glesne & Peshkin, 1992; Ely, Anzul, Friedman, Garner & Steinmetz, 1991; Patton, 1990, 1980; Merriam, 1988; Lincoln & Guba, 1985). The multi-pronged approach of this study, whereby questionnaires and the diagnostic test were supplemented with documentation, classroom observation and interviews, ensured that I stayed clear of a narrow and one-dimensional account of the learners' experiences of transition from GET science to Physical Science in the FET band. The interviews were intended to relate responses from the interest questionnaire to the diagnostic test, the examination and classroom observation. Classroom observation in turn was meant to relate classroom practices to official documentation. Responses from the NOS questionnaire were used to determine epistemological beliefs which in turn determined the extent to which one could integrate knowledge and thus cope with transition. The belief groups were compared with regard to their marks in the examination and also to the responses to the diagnostic test which required conceptual understanding. The triangulation design is used because the strength of each method can be applied to provide not only a more complete result but also one that is more valid (McMillan & Schumacher, 2006).

3.8 ETHICAL CONSIDERATIONS

Once the participants were selected, I obtained their formal, informed consent for participating in the study. Informed consent benefits both the participants and the researcher and ensures that both know their reciprocal rights and expectations (Airasian & Gray, 2003). The participants knew what they were expected to do and they understood any risks involved. They also knew the conditions under which they might withdraw from the study. They were assured that their identities would be protected and that their supervisors would not have access to their individual data.

I am fully aware that trust is earned, not given and that it must be maintained throughout the study: "Trust and rapport in fieldwork are not simply a matter of niceness; a non-coercive, mutually rewarding relationship with key informants is essential if the researcher is to gain valid insights into the informant's point of view" (Erickson, 1990, p. 141).

3.9 CHAPTER SUMMARY

In this four-year longitudinal study a group of learners was followed from grade 9 into the FET band. I used a combination of qualitative and quantitative data collection strategies in order to reduce researcher bias and improve the reliability and validity of the data collected.

CHAPTER FOUR: RESULTS – QUANTITATIVE DATA

4.1. INTRODUCTION

This chapter seeks to use quantitative data to help to answer research questions 2 and 3:

(2) How do learners in the Gauteng province of South Africa experience the transition from Natural Science in the GET phase to Physical Science in the FET phase.

(3) How can the learners' strategies and approaches for negotiating the transition be understood and explained?

Firstly the results of the grade 11 Physical Science examinations:

The achievements of boys and girls in the grade 11 Physical Science final examinations were compared. I then classified learners as high achievers and low achievers on the basis of their achievement and used the examination marks as a baseline to compare interest and epistemological beliefs.

Secondly the results of the interest questionnaire:

Firstly, the reliability of the interest questionnaire was determined. Next I compared the interest in the various sciences in grade 9 according to gender. Then I explored the change in interest in Physical Science as learners moved from GET to FET. Lastly, I explored correlation between interest shown in Physical Science and achievement in the grade 11 Physical Science examinations.

Thirdly the results of the NOS survey:

The NOS survey was used to investigate the learners' scientific epistemological inclinations. I did this by classifying them as empiricist-aligned or post-positivist oriented, on the basis of their scores on the NOS survey. Statistical analysis of the responses to the NOS questionnaire was then carried out to find out if there was a correlation between the NOS scores and achievement in the Physical Science examination. The analysis also explored if there were differences across gender and between the Physical Science and non-Physical Science learners.

Finally the results of the diagnostic test:
The test was administered to assess the content knowledge that the FET learners acquired as well as their strategies for solving conceptual problems.

4.2 THE GRADE 11 EXAMINATION

The examination marks used in this study are those obtained from the 2007 grade 11 Physical Science Paper 2 (Chemistry) examination obtainable from the Department of Education (DoE) website www.education.gov.za. Refer also to the weighting of the Learning Outcomes and examination content for grade 11 Physical Science in Appendix K. The results of the 2007 grade 11 Physical Science paper 2 (Chemistry) are summarized in Table 4.1(a). The v_1 number is the reference number of the learner who wrote the examination.

Table 4.1(a) Achievement in the 2007 grade 11 Physical Science examinations (Chemistry)

V_1	Gender	Exam marks (%)
0026	F	20
0029	F	24
0074	F	30
0145	F	30
0150	F	30
0160	F	30
0142	F	31
0070	F	32
0107	F	32
0149	F	32
0151	F	32
0162	F	32
0021	F	33
0072	F	33
0125	F	33
0146	F	33
0027	F	34
0061	F	34
0101	F	34
0158	F	34
0047	F	35
0130	F	36
0105	F	36
0141	F	37
0050	F	39
0147	F	39
0154	F	39
0076	F	49
0117	F	60
0073	M	32
0063	M	33
0152	M	33
0049	M	34
0013	M	36
0102	M	39
0001	M	48
0086	M	48
0038	M	50
0039	M	50
0058	M	51

Neither I nor the teacher set the examination. It was a national examination. Girls were in the great majority (29 out of 40). The performance was dismal, with only four learners obtaining 50% or more. Table 4.1 (b) shows that the average score for boys is about 7% more than that for girls.

Table 4.1 (b) Descriptive statistics on the Physical Science examination

Variable	N	Mean	SD	Sum	Min	Max
Boys	11	41.27	8.04	454	32	51
Girls	29	34.24	7.03	993	20	60

Was this difference statistically significant? The null hypothesis that had to be tested was: *There is no significant difference between the examination scores of boys and of girls in the Physical Science examination.*

The two-tail t-test revealed that the difference between the examination scores of boys and girls was indeed statistically significant, with p= 0.0099.

4.3 THE INTEREST QUESTIONNAIRE (IQNSFS)

For each item, learners had to indicate on a scale of 0 to 3 how much they would like to do the relevant activity to measure interest in each of the subjects Physical Science, Life Sciences, Mathematics and Computer Science. The preferred response was to be indicated by using the following code:

0 = Would never do it
1 = Don't like it , but may do it
2 = Like it slightly
3 = Like it very much

The interest questionnaire (given in Appendix A) was administered to 417 learners, 3 short of the intended number of 420. Table 4.2 shows the number of grade 9 learners in the sample: the intended number of learners, the number of questionnaires that were either used or spoilt, the actual number of questionnaires used in the study and the percentage usable questionnaires. The unused questionnaires reflected the fact that some learners were absent on the day the questionnaires were administered, or they were simply not returned.

Table 4.2 The number of grade 9 learners in the sample.

Participating school	Intended sample: number of learners	Number of questionnaires unused/spoilt	Actual sample: number of questionnaires used in the study			% usable questionnaires
	Total	Total	Boys	Girls	Total	%
A	162	0	66	96	162	100
B	258	3	117	138	255	99
TOTAL	420	3	183	234	417	99

4.3.1 Reliability of the interest questionnaire

To know more about the contribution of an item to the subject to which it belongs, Tables 4.3 to 4.6 show correlation of scores for test items within each of the subjects Physical Science, Life Sciences, Mathematics and Computer Science. The Cronbach alpha coefficients were used for this purpose (Swanepoel, 1986). The V numbers in the tables are the reference number of the items in the questionnaire.

Table 4.3 Correlation and reliability of items for Physical Science

Item number	V number	Cronbach's alpha-coefficient		
		Overall	Boys	Girls
1	v3	0.852	0.859	0.846
4	v6	0.855	0.861	0.848
5	v7	0.854	0.861	0.848
14	v16	0.852	0.857	0.847
19	v21	0.850	0.852	0.847
20	v22	0.850	0.852	0.846
23	v25	0.848	0.850	0.847
29	v31	0.845	0.847	0.843
32	v34	0.846	0.848	0.842
35	v37	0.850	0.857	0.845
37	v39	0.845	0.848	0.842
43	v45	0.849	0.856	0.843
48	v50	0.852	0.857	0.848
52	v54	0.847	0.854	0.841
59	v61	0.845	0.850	0.840
63	v65	0.849	0.856	0.842
69	v71	0.850	0.855	0.844
70	v72	0.847	0.853	0.842
77	v79	0.845	0.850	0.840
81	v83	0.843	0.847	0.838
84	v86	0.845	0.853	0.838

The consistently high Cronbach alpha-coefficient for the items in Physical Science in Table 4.3 showed that none of the items in Physical Science had to be rejected from the questionnaire – the test was internally consistent.

Table 4.4 Correlation and reliability of items for Life Sciences

Item number	V number	Cronbach's alpha-coefficient		
		Overall	Boys	Girls
6	v8	0.882	0.887	0.879
10	v12	0.881	0.884	0.879
11	v13	0.880	0.885	0.877
15	v17	0.880	0.885	0.877
17	v19	0.883	0.887	0.880
22	v24	0.883	0.887	0.881
26	v28	0.882	0.886	0.879
33	v35	0.882	0.888	0.878
38	v40	0.879	0.886	0.873
41	v43	0.878	0.885	0.873
44	v46	0.878	0.884	0.873
45	v47	0.880	0.885	0.877
53	v55	0.877	0.882	0.873
55	v57	0.879	0.885	0.873
62	v64	0.879	0.884	0.876
67	v69	0.879	0.886	0.873
71	v73	0.879	0.883	0.876
74	v76	0.878	0.882	0.875
76	v78	0.878	0.884	0.872
80	v82	0.878	0.884	0.873
83	v85	0.877	0.884	0.872

Table 4.4 also showed high reliability coefficients. The consistently high Cronbach alpha-coefficients for the items in Life Sciences in Table 4.4 showed that none of the items in Life Sciences had to be rejected from the questionnaire – the test was internally consistent.

Table 4.5 Correlation and reliability of items for Mathematical Sciences

Item number	V number	Cronbach's alpha-coefficient		
		Overall	Boys	Girls
2	v4	0.867	0.871	0.864
7	v9	0.871	0.875	0.870
9	v11	0.865	0.870	0.862
12	v14	0.865	0.869	0.864
18	v20	0.868	0.873	0.866
25	v27	0.861	0.867	0.858
28	v30	0.862	0.869	0.858
31	v33	0.874	0.879	0.871
34	v36	0.868	0.873	0.865
42	v44	0.867	0.874	0.863
47	v49	0.865	0.870	0.862
50	v52	0.858	0.862	0.857
51	v53	0.865	0.873	0.861
56	v58	0.866	0.873	0.862
58	v60	0.860	0.867	0.856
61	v63	0.863	0.871	0.858
66	v68	0.866	0.870	0.863
72	v74	0.860	0.865	0.857
75	v77	0.859	0.865	0.855
78	v80	0.866	0.872	0.861
82	v84	0.859	0.865	0.855

The consistently high Cronbach alpha-coefficient for the items in Mathematical Sciences in Table 4.5 showed that none of the items in Mathematical Sciences had to be rejected from the questionnaire – the test was internally consistent.

Table 4.6 Correlation and reliability of items for Computer Sciences

Item number	V Number	Cronbach's alpha-coefficient		
		Overall	Boys	Girls
3	v5	0.865	0.882	0.849
8	v10	0.864	0.881	0.848
13	v15	0.862	0.882	0.842
16	v18	0.861	0.877	0.845
21	v23	0.860	0.879	0.842
24	v26	0.861	0.877	0.845
27	v29	0.864	0.880	0.848
30	v32	0.857	0.875	0.840
36	v38	0.856	0.876	0.836
39	v41	0.860	0.878	0.843
40	v42	0.858	0.877	0.840
46	v48	0.861	0.879	0.843
49	v51	0.859	0.876	0.841
54	v56	0.862	0.882	0.843
57	v59	0.857	0.876	0.839
60	v62	0.857	0.875	0.840
64	v66	0.861	0.882	0.840
65	v67	0.861	0.879	0.843
68	v70	0.860	0.880	0841
73	v75	0.867	0.885	0.850
79	v81	0.861	0.881	0.843

Table 4.6 showed a consistently high reliability coefficient for Computer Science items. The high Cronbach alpha-coefficient for the items in Computer Sciences in Table 4.6 showed that none of the items in Computer Sciences had to be rejected from the questionnaire – the test was internally consistent.

4.3.2 Subject preferences of grade 9 learners

Arithmetic means and medians form the basis of item analysis (Table 4.7) to determine the level of interest shown by boys and girls in the different subjects. This table should be studied in conjunction with Appendix B which indicates the number of respondents for each item.

Table 4.7 The arithmetic means, standard deviations and medians according to subject and gender

Subject	Gender	Total number	Arithmetic mean	Standard deviation	Median
PS	Overall	417	1.74	0.49	1.76
	Boys	183	1.79	0.51	1.81
	Girls	234	1.70	0.48	1.70
LS	Overall	417	1.70	0.52	1.71
	Boys	183	1.69	0.53	1.67
	Girls	234	1.71	0.51	1.71
MS	Overall	417	1.82	0.53	1.86
	Boys	183	1.81	0.54	1.86
	Girls	234	1.83	0.52	1.83
CS	Overall	417	2.35	0.44	2.43
	Boys	183	2.39	0.46	2.48
	Girls	234	2.31	0.43	2.31

So, using a scale that ranges from 0 to 3, the midpoint would be 1.5. It is clear from Table 4.7 that the arithmetic means and the medians are all above 1.5. So there was no aversion for any particular subject.

Having shown that each one of the 4 tests measuring interest in a specific subject was internally consistent, I proceeded with the formulation of the null hypotheses.

It was important first to find out if there was any significant difference between boys and girls with regard to their interest in the different subjects. If there was a significant difference between boys and girls with regard to interest in the different subjects, then parallel studies, one for boys and another one for girls, wouldl have to be conducted to determine how learners experience transition from GET to FET.

The following null hypotheses were formulated:

- *There is no significant difference between grade 9 boys and girls with regard to interest shown for Physical Sciences.*
- *There is no significant difference between grade 9 boys and girls with regard to interest shown for Life Sciences.*
- *There is no significant difference between grade 9 boys and girls with regard to interest shown for Mathematical Sciences.*
- *There is no significant difference between grade 9 boys and girls with regard to interest shown for Computer Sciences.*

The null hypotheses were tested using a t-test and the results captured in Table 4.8.

Table 4.8 T-test comparison of boys' and girls' interest in scientific subjects

Subject	t-value	p-value
Physical Science	1.81	0.0708
Life Science	-0.57	0.5672
Mathematical Science	-0.47	0.6407
Computer Science	1.72	0.0867

Table 4.8 indicates that the null hypotheses could not be rejected. In particular:

- *There is a tendency to differ between grade 9 boys and girls with regard to interest shown for Physical Science. Table 4.7 shows that there is a higher arithmetic mean for boys. The t-test, however, shows that this difference is statistically insignificant because the p-value is slightly greater than 0.05.*

- *There is no significant difference between grade 9 boys and girls with regard to interest shown for Life Sciences (p value > 0.05). Table 4.7 shows a higher arithmetic mean for girls, but the t-test reveals that this difference is statistically insignificant.*

- *There is no significant difference between grade 9 boys and girls with regard to interest shown for Mathematical Sciences (p value > 0.05). Table 4.7 shows a higher arithmetic mean for girls but the t-test reveals that this difference is not statistically significant.*

- *There is a tendency to differ between grade 9 boys and girls with regard to interest shown in Computer Sciences. Table 4.7 shows that there is a higher arithmetic mean for boys. The t-test, however, shows that this difference is not statistically significant because the p-value is slightly greater than 0.05.*

4.3.3 Change in interest from grade 9 to grade 10

Table 4.9 compares the mean scores of the interest test in Physical Science of the learners when they were in grade 9 to those when they were in grade 10. Results are shown separately for boys and girls.

Clearly, interest in Physical Science increased for girls, boys and the overall group during their transition from grade 9 to grade 10. The question arose, were these increases significant?

Table 4.9 Change in average scores in the Physical Science Interest questionnaire for learners when progressing from grade 9 to grade 10

	Number	Grade 9 average	Grade 10 average	Increase
Boys	16	1.62	2.06	0.44
Girls	45	1.88	1.97	0.09
Overall	61	1.81	1.99	0.18

The following null hypotheses were formulated:

- *There is no significant difference between boys in grade 9 (GET) and the same boys in grade 10 (FET) with regard to interest shown for Physical Science.*

- *There is no significant difference between girls in grade 9 (GET) and the same girls in grade 10 (FET) with regard to interest shown for Physical Science.*
- *There is no significant difference between learners in grade 9 (GET) and the same cohort of learners in grade 10 (FET) with regard to interest shown for Physical Science.*

The hypotheses were tested and the results given in Table 4.10

Table 4.10 T-test comparison of interest in Physical Science in grade 9 and grade 10

Sample	Number of learners	t-value	p-value
Overall	61	2.69	0.0092
Boys	16	2.74	0.0153
Girls	45	1.35	0.1845

Table 4.10 indicates that:

- There is a significant difference between boys in grade 9 (GET) and the same boys in grade 10 (FET) with regard to interest shown for Physical Science ($p < 0.05$). Table 4.9 does indicate an increase in interest in Physical Science as boys moved from grade 9 to grade 10. Table 4.10 shows that this difference is indeed significant.
- There is no significant difference between girls in grade 9 (GET) and the same girls in grade 10 (FET) with regard to interest shown for Physical Science ($p > 0.05$). Although Table 4.9 indicates a slight increase in interest in Physical Science as girls moved from grade 9 to grade 10, this difference is not significant (Table 4.10).
- There is a significant difference between learners in grade 9 (GET) and the same cohort of learners in grade 10 (FET) with regard to interest shown for Physical Science ($p < 5$). Table 4.9 does indicate an increase in interest in Physical Science as all learners together moved from grade 9 to grade 10. Table 4.10 shows that this difference is indeed significant.

4.3.4 Correlation between achievement in the grade 11 examinations and interest

A possible correlation between interest and performance in Physical Science was explored to shed light on learners' experiences and coping with the transition. Table 4.11 shows the scores in

Table 4.11 Interest in Physical Science versus achievement in the Physical Science examinations

V_1	Gender	Exam marks (%)	Interest (max 63)
0026	F	20	37
0029	F	24	36
0074	F	30	47
0145	F	30	51
0150	F	30	41
0160	F	30	51
0142	F	31	40
0070	F	32	42
0107	F	32	40
0149	F	32	48
0151	F	32	44
0162	F	32	42
0073	M	32	56
0021	F	33	51
0072	F	33	35
0125	F	33	46
0146	F	33	52
0063	M	33	39
0152	M	33	58
0027	F	34	27
0061	F	34	53
0101	F	34	51
0158	F	34	35
0049	M	34	57
0047	F	35	54
0130	F	36	35
0105	F	36	54
0013	M	36	50
0141	F	37	39
0050	F	39	55
0147	F	39	59
0154	F	39	56
0102	M	39	45
0001	M	48	49
0086	M	48	36
0076	F	49	41
0038	M	50	60
0039	M	50	31
0058	M	51	60
0117	F	60	34

the grade 11 examinations as well as in the interest questionnaire. The Interest score in Table 4.11 was calculated for Physical Science only. It was calculated by adding all the scores for each Physical Science item. The possible maximum score was 63 (3 x 21 Physical Science items).

The following null hypothesis was formulated:

> *There is no significant correlation between interest in Physical Science and achievement in the Physical Science examinations.*

Descriptive statistics on interest and examination score are displayed in Table 4.12 and a scatter-plot is shown in Figure 4.1.

Table 4.12: Descriptive statistics on Interest score and Examination marks

Variable	N	Mean	Standard Deviation	Sum	Min	Max
Exam	40	36.18	7.89	1447	20	60
Interest	40	45.93	8.89	1837	27	60

The Pearson correlation coefficient was found to be $r = 0.04043$ with $p = 0.8044$. This means that there was no significant correlation between interest and achievement in the Physical Science examination ($p > 0.05$). This finding was corroborated by the scatter-plot of Examination vs. Interest (Figure 4.1).

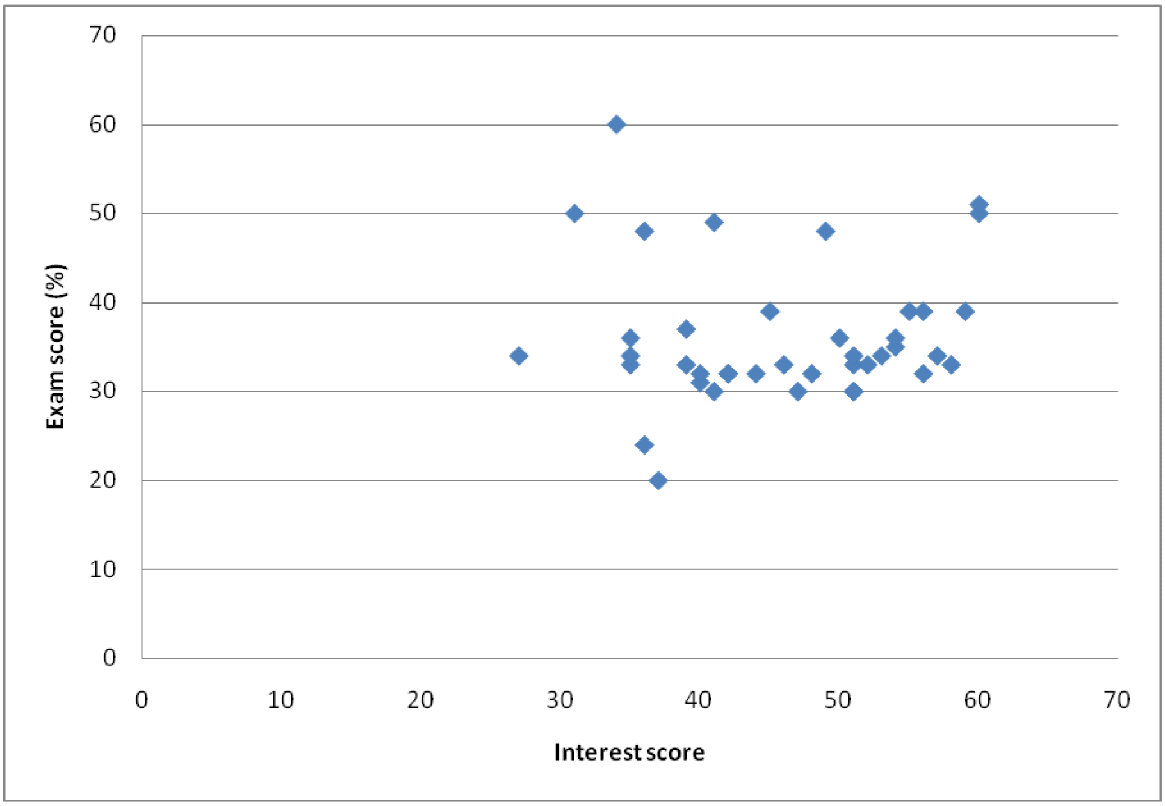


Figure 4.1 Scatter-plot of Examination score vs. Interest score

4.3.5 Summary of results of the interest questionnaire

The interest questionnaire was shown to be reliable. Some authors, e.g. Mulder (1986), regard a correlation coefficient of 0.4 to 0.59 as a moderate correlation and 0.6 to 0.79 as a high correlation. Tables 4.3 to 4.6 therefore indicate a very high correlation, showing that the homogeneity of each of the 4 subject interest tests is satisfactory.

There was an indication of a high preference for Computer Studies amongst grade 9 learners. It was interesting that the schools from which the learners come do not offer Computer Studies. This preference could be due to the fact that Computer Studies are linked to the world of work. According to the DoE (1997), there should be clear evidence that the Senior Phase learner is being prepared for life after school, i.e. life in the world of work, at institutions for further learning and for adult life in general. Learning programmes should create opportunities for the learner to be informed about career and further learning opportunities, about ways and means of realising his/her expectations for the future, and about his/her rights and responsibilities as a citizen in a democratic, multicultural society (DoE, 1997).

The finding that there was no significant difference between boys and girls in grade 9 with regard to interest in the so-called 'hard' subjects like Physical Science and Mathematics augers well for the future of this country. For years these subjects have been regarded as the boys' domain. However, in progressing to grade 10, it was found that interest in science increased significantly for boys but not for girls. This could be an indication that boys were coping better with the transition.

The finding of a significant difference between learners in grade 9 (GET) and the same cohort of learners in grade 10 (FET) with regard to interest shown for Physical Science ($p < 0.05$) should be treated with caution. This is a finding at the interface of GET and FET (i.e. end of grade 9 and the beginning of grade 10) and not over the overall gap as defined in the theoretical framework in Chapter 2. It still needed to be seen if this interest would be maintained throughout the FET phase. The increase in interest could be due to the learners' expectations of what Physical Science was holding for them and not due to actual experience through the FET phase.

Not surprising was the finding that there was no correlation between interest and achievement in the Physical Science examination. Interest in Physical Science may for example, be prompted by role models and job opportunities and in may not be caused by achievement or intellectual ability.

4.4 THE NATURE OF SCIENCE SURVEY

In this study I have adopted the Nature of Scientific Knowledge Scale (NSKS) and its subscales developed by Rubba and Anderson (1978), to explore whether learners' epistemological inclination affected their experiences of the transition.

4.4.1 Epistemological beliefs

The learners were classified as post-positivist-oriented or empiricist-aligned based on their score on the NOS survey. In the classification, the cut-off point was the mean score.

Table 4.13a Exam score, NSKS score and belief classification of the Physical Science group

V_1	Gender	Exam marks (%)	NSKS score	Belief group
58	F	32	139	Empiricist aligned
52	F	32	140	
59	F	34	146	
54	F	32	147	
49	F	30	149	
11	F	20	150	
24	M	34	152	
47	F	37	154	
41	M	39	154	
18	M	50	154	
30	M	33	155	
17	M	50	155	
56	F	39	156	
31	F	33	157	
48	F	31	158	
35	M	48	158	
13	F	24	159	
29	F	34	159	
34	F	49	159	
33	F	30	160	
12	F	34	160	
60	F	36	160	
44	F	33	162	Post positivist oriented
25	F	32	164	
55	M	33	164	
53	F	30	165	
42	F	32	166	
45	F	36	166	
07	M	36	166	
57	F	30	167	
09	F	33	167	
21	F	35	167	
43	F	60	167	
40	F	34	169	
51	F	39	170	
50	F	33	171	
32	M	32	171	
23	F	39	173	
01	M	48	174	
28	M	51	175	

The post positivist-oriented learners were those that have scored above the mean and the rest are empiricist-aligned. Tables 4.13(a) shows that the classification may turn out to be an oversimplification as the NSKS scores did not vary much.

Descriptive data on the examination and NSKS scores are given in Table 4.13(b). The mean scores for boys in the examination and the NSKS are above those for the whole class, while the means for girls in the examination and the NSKS are below those for the whole class.

Table 4.13b Descriptive statistics on the examination and NSKS scores

Variable	Group	N	Mean	Sum	Min	Max
Exam	Overall	40	36.18	1447	20	60
	Boys	11	41.27	454	32	51
	Girls	29	34.24	993	20	60
NSKS	Overall	40	160.12	6405	139	175
	Boys	11	161.64	1778	152	175
	Girls	29	159.55	4627	139	173

Next I compared learners taking Physical Science and a group of learners not taking Physical Science. This group studied Commercial Sciences and Mathematics. Table 4.14 shows the NSKS scores of the non-Physical Science learners. Table 4.15 compares the NSKS scores between Physical Science and Commercial science groups on all the six subscales.

The following null hypothesis was tested:

- *The is no significant difference between the scores of learners who are taking Physical Science and those who are not taking Physical Science on the six NSKS subscales shown in Table 4.16.*

Table 4.14 NSKS scores of the Commercial Science group

V_1	Gender	NSKS score
02	F	157
03	F	168
04	F	159
05	F	163
06	M	157
08	F	146
10	F	140
14	F	142
15	F	162
16	M	160
19	F	136
20	F	162
22	F	150
26	F	166
27	M	169
36	F	141
37	F	164
38	M	144
39	F	158
46	M	167

Table 4.15 Descriptive statistics on the NSKS scores of the Physical Science group and the Commercial Science group

Subscale/Scale	Physical Science (N = 40)		Commercial Science (N = 20)	
	Mean	Std Deviation	Mean	Std Deviation
Amoral	23.875	0.4542	24.300	0.6223
Creative	29.500	0.7748	27.600	1.0958
Developmental	24.225	0.5211	24.500	0.7369
Parsimonious	23.250	0.4307	23.600	0.6091
Testable	29.950	0.4405	26.700	0.6229
Unified	29.325	0.6854	28.350	0.9692
NSKS	160.125	1.4771	155.250	2.0890

Table 4.16 gives the comparison of NSKS scores of the Physical Science and Commercial Science groups using the t-test.

Table 4.16 T-test Comparison of NSKS scores of the Physical Science and Commercial Science groups

Subscale/Scale	t	P
Amoral	-0.54	0.5911
Creative	1.42	0.1622
Developmental	-0.30	0.7617
Parsimonious	-0.47	0.6407
Testable	4.26	<0.0001
Unified	0.65	0.5164
NSKS	1.91	0.0617

The t-test showed that:

- T*here is a significant difference between the Physical Science group and the Commercial Science group with regard to the testable subscale score ($p < 0.05$), but no significant difference between any of the other subscales.*

From Table 4.16 it was evident that there was a tendency to differ between the Physical Science group and the Commercial Science group with regard to the whole NSKS score but it is not significant. ($p = 0.0617 > 0.05$). The Physical Science group has a higher mean, but the t-test revealed that this difference was not statistically different, although the p value was close to .05.

In summary, it was concluded that learners taking Physical Science scored significantly higher on only the testable subscale of NSKS test when compared to the Commercial Science group.

Next, the NSKS scores for boys and girls taking Physical Science were compared. The following null hypothesis was tested:

- *There is no significant difference between the scores of boys taking Physical Science and those of girls taking Physical Science on all the six NSKS subscales shown in Table 4.18.*

Table 4.17 shows the descriptive statistics for boys and girls. The boys scored almost more than 2 points higher on the developmental subscale.

Table 4.17 Descriptive statistics on NSKS scores between the Physical Science boys and girls.

Subscale/Scale	Physical Science boys (N = 11)		Physical Science girls (N = 29)	
	Mean	Std Deviation	Mean	Std Deviation
Amoral	24.727	0.8547	23.551	9.5264
Creative	28.727	1.2517	29.793	0.7709
Developmental	26.364	1.0440	23.414	0.6430
Parsimonious	22.272	0.8653	23.621	0.5330
Testable	29.818	0.9040	30.000	0.5568
Unified	29.727	1.3923	29.172	0.8575
NSKS	161.636	2.6913	159.551	1.6576

Table 4.18 shows the t-test comparison of NSKS scores between the Physical Science boys and girls.

Table 4.18 T-test comparison of NSKS scores of boys and girls

Subscale/Scale	t	P
Amoral	1.17	0.2488
Creative	-0.73	0.4729
Developmental	2.41	0.0211
Parsimonious	-1.33	0.1926
Testable	-0.17	0.8649
Unified	0.34	0.7362
NSKS	0.66	0.5135

From table 4.18, it is clear that the t-test showed that the null hypotheses could be rejected only in the case of the developmental subscale, therefore it was concluded that boys scored significantly higher than girls with regard to the developmental subscale score ($p < 0.05$).

4.4.2 Correlation between achievement and NSKS scores

First the Physical Science group was divided into post positivist and empiricist sub-groups and their achievement in the examination compared (refer to Tables 4.13(a) and 4.19). The following null hypothesis was tested:

- *There is no significant difference between the achievement of the post positivists and empiricists.*

Next, the correlation between the NSKS scores of the entire Physical Science group (both belief groups combined) and their achievement in the 2007 grade 11 Physical Science examinations was compared. The null hypothesis was:

- *There is no correlation between the NSKS scores and achievement in the Physical Science examinations.*

Table 4.19 shows the descriptive statistics on the examination marks obtained by the two belief groups.

Table 4.19 Descriptive statistics on the examination marks of Post-positivists and Empiricists

Variable	N	Mean	Sum	Min	Max
Post positivist	18	37.0	666	30	60
Empiricist	22	35.5	781	20	50

Table 4.19 showed that the post positivist-oriented learners performed better than the empiricist-aligned learners in the Physical Science examinations. However, the difference was not statistically significant (p-value = 0.556).

The correlation between the NSKS score and examination achievement is rather weak with the Pearson correlation coefficient calculated at r = 0.25 and a p-value of 0.1188.

This finding is corroborated by the scatter-plot of Examination vs. NSKS shown in Figure 4.2.

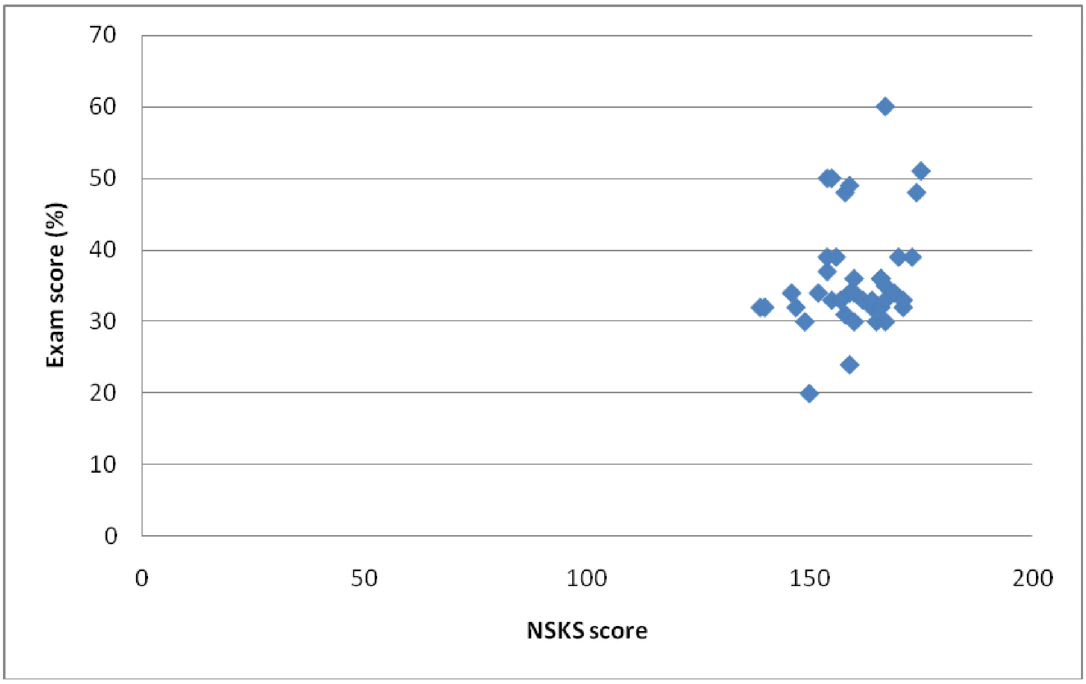


Figure 4.2 Scatter-plot of Examination score vs. NSKS score

4.4.3 Summary of the NOS survey results

- Learners in this study were classified as empiricist aligned or post positivist oriented. There is no significant difference between the achievement of the post positivists and empiricists in the grade 11 Physical Science examinations.
- There was no correlation between scores on the NSKS and the 2007 grade 11 Physical Science examinations.
- There was no significant difference between the NSKS scores of the Physical Science and Commercial science groups with regard to all the subscales except for the testable subscale.
- There was no significant difference between the NSKS scores of the Physical Science boys and Physical Science girls with regard to all the subscales except for the developmental subscale.

4.5 THE DIAGNOSTIC TEST

The results of the diagnostic test for individual student were given in Table 4.20.

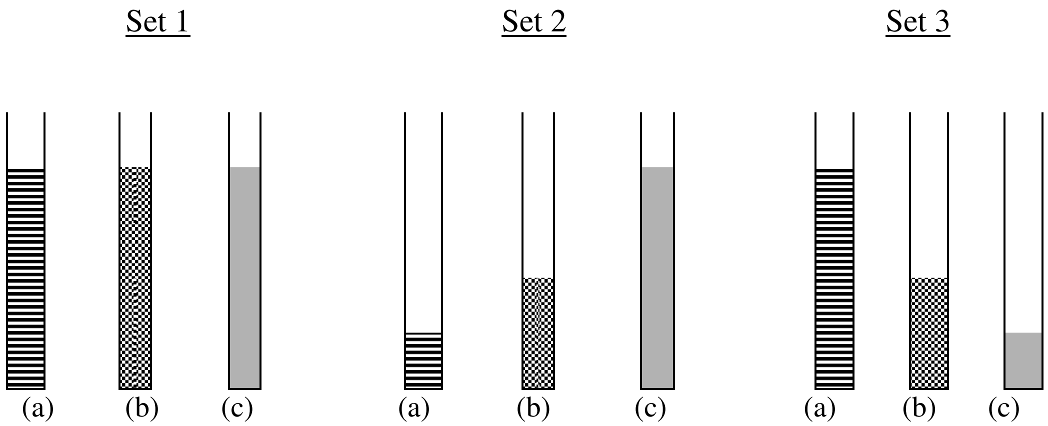
Table 4.20 Diagnostic Test: score per question with confidence levels in brackets

V_1	Gender	Age	Q1(3 marks)	Q2(3marks)	Total (6 marks)
01	M	17	0 (100%)	0 100%)	0
09	F	17	0(50%)	1(50%)	1
11	F	19	0(50%)	0(50%)	0
12	F	17	0(50%)	1(50%)	1
13	F	19	0(50%)	1(50%)	1
17	M	17	0(50%)	0(50%)	0
18	M	18	1(50%)	1(50%)	2
21	F	17	0 (50%)	0 (0%)	0
23	F	17	1(50%)	0 (50%)	1
24	M	17	1(50%)	0(50%)	1
25	F	17	0 (0%)	0 (0%)	0
28	M	18	1(50%)	0(50%)	1
29	F	18	0(50%)	0 (0%)	0
30	M	18	1(50%)	0 (0%)	1
31	F	17	0 (0%)	1(0%)	1
32	M	17	0(50%)	0(50%)	0
33	F	17	0(50%)	0(50%)	0
34	F	17	1(100%)	0 (100%)	1
40	F	17	1 (50%)	1(50%)	2
41	M	19	0 (50%)	0(50%)	0
42	F	18	1(50%)	0 (0%)	1
43	F	17	2(0%)	2(0%)	4
44	F	17	2(50%)	0(50%)	2
45	F	17	0(50%)	1(50%)	1
47	F	17	0(50%)	0 (0%)	0
48	F	17	0(50%)	0 (0%)	0
49	F	18	0 (50%)	1(50%)	1
50	F	18	0 (50%)	0 (50%)	0
51	F	17	0 (50%)	1(0%)	1
52	F	18	1(50%)	2(50%)	3
53	F	17	0(50%)	0(50%)	0
54	F	18	0(50%)	0(50%)	0
55	M	17	0(50%)	1(50%)	1
56	F	17	0(50%)	0 (100%)	0
57	F	17	1(0%)	1(0%)	2
58	F	18	0(50%)	0(50%)	0
59	F	18	0(50%)	1(50%)	1
60	F	17	0 (50%)	0 (50%)	0

The table shows scores as well as the confidence levels indicated by students. Results for the two questions are discussed separately in the next two sections.

4.5.1 Question 1

Which of these three sets best shows 1 mole of tin, 1 mole of magnesium and 1 mole of sulphur in each tube?



(a) - tin
(b) - magnesium
(c) - sulphur

key: Set 1 - equal volumes
Set 2 - equal masses
Set 3 - equal number of atoms

Table 4.21 shows the response pattern for question 1. It also indicates the number of learners indicating a particular confidence level when giving a particular response. The number of subjects who chose set 1 (37% of all subjects) is quite large. They probably chose it because the textbook emphasizes that equal volumes of gases are a measure of equal numbers of particles, based on Avogadro's hypothesis (the subjects did not restrict Avogadro's hypothesis to gases). Only 26% of the subjects chose the right answer but none of them gave the correct explanation nor did they respond with 100% confidence. Two of them were not sure at all whether they were correct (0% confidence level)

Figure 4.3 is a diagrammatic representation of the confidence levels. It was clear from the diagram that the majority of subjects only had a 50% confidence level for each response they gave. The learners seemed to resort to rote learning when studying the mole, one of the very basic concepts in chemistry. The question may also be posed, could this be due to poor teaching?

Table 4.21 Response patterns for Question 1

Answers	Total number of respondents	Number with 100% confidence	Number with 50% confidence	Number with 0% confidence
Set 1 (equal volumes)	14	1	12	1
Set 2 (equal mass)	11	0	10	1
* Set 3 (equal numbers of atoms)	10	1	7	2
Other [a]	3	0	3	0
TOTAL	38	2	32	4

* denotes the correct response

[a] Other responses such as tin/all/none

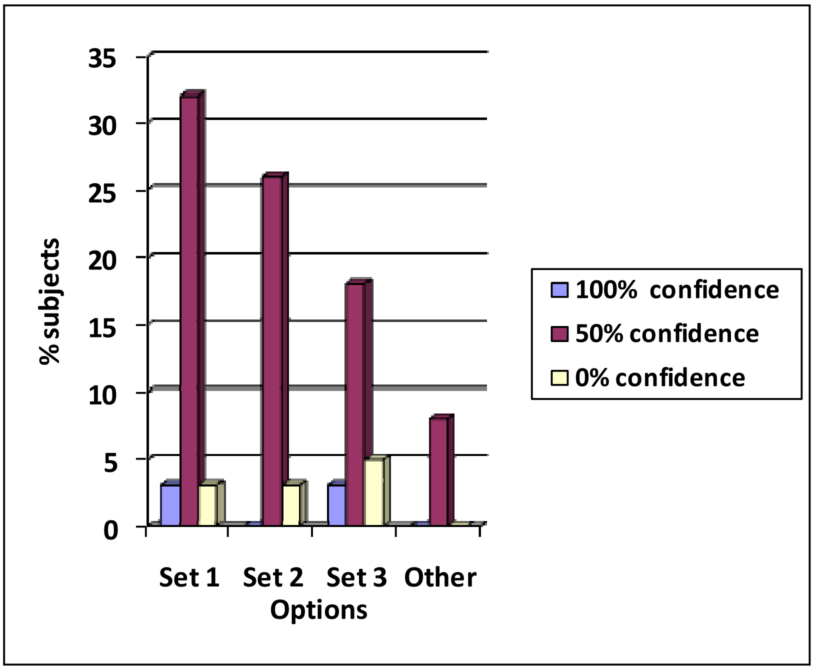
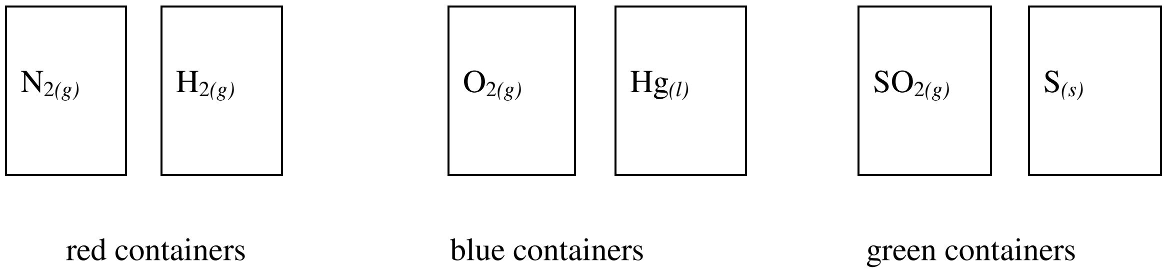


Figure 4.3 Response patterns for Question 1

4.5.2 Question 2

Each container represents a volume of 22,4*l* at S.T.P. In which of the three pairs of containers, if any, is there one mole in each container?



The subjects were asked to give reasons for their choice as well as for not choosing others. The response patterns are given in a Table 4.22 and a summary is given in a bar graph in Figure 4.4. A correct response would be: "The red containers contain one mole because the contents are gases at 22.4l at S.T.P. In the other pairs one of the containers has a liquid or a solid. These are much denser than the gases and therefore consist of much more than one mole of particles".

Table 4.22 Response patterns for Question 2

Answers	Total number of respondents	Number with 100% confidence	Number with 50% confidence	Number with 0% confidence
*Red containers (N_2(g) and H_2(g))	14	0	10	4
Blue containers (O_2(g) and Hg(l))	13	0	8	5
Green containers (SO_2(g) and S(s))	9	1	6	2
Other [a]	2	2	0	0
TOTAL	38	3	24	11

*Denotes the correct response

[a] Other responses such as none/all

Although the largest proportion (37% of all the subjects) gave the right answer, none of them provided the correct motivation nor indicated 100% confidence. The similarity in the number of atoms for each of the gas molecules in the red containers could have made it a plausible option for some subjects. Four of them were very unsure about their answers (0% confidence level). The response of those who said all containers had one mole was consistent with the misconception that Avogadro's hypothesis applied to all phases of matter.

Figure 4.4 diagrammatically illustrates the confidence levels for Question 2. It is clear from the diagram that the majority of the subjects responded with a mere 50% confidence level. That meant that they were not sure if they had the right answers.

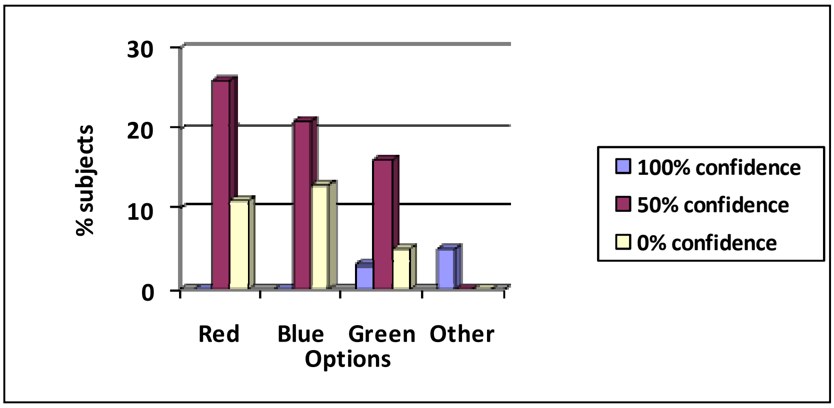


Figure 4.4 Response patterns for Question 2

Interviews with the learners would shed more light on their strategies of coping with conceptual problems. The interviews were discussed in the next chapter.

4.5.3 Discussion of diagnostic test results

Science education literature is replete with reports of studies relating to the identification, explanation and amelioration of students' difficulties in understanding science concepts. Such difficulties have been characterised in various ways, for example, as *misconceptions* (Fisher, 1983), *alternative frameworks* (Driver & Easley, 1978), *intuitive beliefs* (McCloskey, 1983), *spontaneous reasoning* (Viennot, 1979), *children's science* (Osborne, Bell & Gilbert, 1983) and *naive beliefs* (Caramazza, McCloskey & Green, 1981). In this study the term 'misconception' is used as defined by Cho, Kahle and Nordland (1985) to include any conceptual idea whose meaning deviates from the one commonly accepted by scientific consensus. In their description of origins of misconceptions and possible reasons for learners' lack of understanding, Garnett and Treagust (1990) identified five problem areas, namely: compartmentalization of subject knowledge; learners' interpretation of language; the use of multiple definitions and models; inadequate pre-requisite knowledge; and the rote application of concepts and algorithms.

Research on problem-solving and misconceptions in chemistry shows that chemistry is a very complex subject. Students have misconceptions and solve problems using algorithms because of the complex nature of chemistry concepts and because of the way the concepts are taught. Many of the concepts studied in chemistry are abstract and are difficult to explain without the use of analogies or models (Gabel, 1999). The diagnostic test used in the current study was based on the mole concept, one of the basic concepts in chemistry. In a survey done among teachers in the USA to determine the most difficult concepts to teach and learn, the mole was rated second only to chemical equilibrium (Aird, 1989). Perhaps it is not surprising then, to see the extremely poor results in Table 4.21 and Table 4.22.

From the responses to the diagnostic test, it would appear that:

- Learners were labouring under misconceptions or lack of knowledge of the mole.
- Learners resorted to rote application of concepts and algorithms as well as guess work when they were faced with a test in which conceptual understanding is emphasized.
- Learners were not confident about their answers.

These problems with conceptual understanding will have to be resolved in order to make transition smooth for learners moving from GET (Natural Science) to FET (Physical Science) and throughout the FET.

4.6 CHAPTER SUMMARY

Learners' interest in science and epistemological stance were assessed, using achievement in the examinations as a basis for comparison. Also, conceptual understanding, problem solving skills and confidence were assessed by means of a diagnostic test.

Interest Questionnaire for the Natural Science Field of Study (IQNSFS)

- Grade 9 boys and girls had similar interests in the four subjects and they preferred Computer Science.
- Transition from grade 9 to grade 10: Interest in Science increased significantly for boys and the overall group but not significantly for girls.
- There was no correlation between interest and achievement in the Physical Science examination.

The Nature of Science Survey

- There was no significant correlation between the NSKS scores and achievement in the examination. This means that a learner does not necessarily do well in the examinations because s/he has done well in the NSKS – the correspondence in the few scores between the two (examination and NSKS) can rather be ascribed to a third variable like ability or the role that memory plays or in the way in which the subjects are presented (Mulder, 1986).
- Physical Science learners scored significantly higher on the subscale 'testable' than Commercial Science learners. It seemed that they believe that scientific knowledge must be testable in order to be acceptable.
- Boys scored significantly higher on the subscale 'developmental' than girls. The boys scored higher (above the mean) in the NSKS and significantly higher in the examination. The girls scored lower (below the mean) in both the examinations and NSKS. On the basis of the significantly higher score on the developmental subscale as well as the significantly higher exam marks, the boys then tended to be high achieving post positivists and girls low achieving empiricists in general.

Diagnostic Test

- The test had shown a very poor conception of the mole – a basic concept in chemistry. It has also exposed rote application of concepts and algorithms. It was also clear that learners were aware of their poor understanding and poor problem solving skills, hence large degree of uncertainty about their answers.

CHAPTER FIVE: RESULTS – QUALITATIVE DATA

5. 1 INTRODUCTION

This chapter used qualitative data to explore all three research questions:

1. How can the transition from the Natural Science in GET to the Physical sciences in the FET be characterized?
2. How do learners in the Gauteng province of South Africa experience the transition from Natural Science in the GET phase to Physical Science in the FET phase?
3. How can learners' strategies and approaches for negotiating the transition be understood and explained?

The chapter starts with a general background that discusses documentation on the Natural Science (grade 9) curriculum and the Physical Science (grade 10) curriculum. I then discussed the analysis of the curricula for scope of coverage, depth of coverage and prerequisite knowledge. The matching of the curricula is in terms of how the GET science (particularly the grade 9 Natural Science) fitted in with the Physical Science in FET, and also whether it provided an adequate basis for learners to study Physical Science in FET.

I focussed on classroom observation to explore the teaching style, content knowledge of the learners and leaner interaction, and finally on interviews to hear from learners themselves how they experienced the transition. Interviews attempted to make sense of the cognitive processes that accompany learners' responses (Confrey, 1990). The chapter ends with comments on the results from the qualitative data.

5.2 DOCUMENTATION

In 2005, learners in the GET phase (grade R to grade 9) followed C2005 with the following design features (DoE, 2006(a)):

- 7 Critical and 5 Developmental Outcomes
- 9 Specific Outcomes (Natural Science)

- Assessment Criteria
- Range Statements
- Performance Indicators
- Phase Organisers
- Programme Organisers
- Notional Time

When the learners entered the FET band in 2006, they followed the NCS, a curriculum with streamlined design features (DoE, 2006(a)):

- 7 Critical and 5 Developmental Outcomes
- 3 Learning Outcomes (Natural Science)
- 10 Assessment Standards.

In both bands (the GET and the FET bands) the Critical and Developmental Outcomes stayed the same.

The 9 Natural Science Specific Outcomes were streamlined to 3 Learning Outcomes.

The Assessment Criteria, Range Statements and Performance Indicators have all been streamlined into grade-specific Assessment Standards.

The role and content of Phase Organisers and Programme Organisers have been incorporated into the Learning Outcomes and Assessment Standards.

5.2.1 Changes in prescribed content

In 2005, the grade 9 Natural Science content was left almost entirely to the discretion of the teacher and the school. From 2006, in grade 10 Physical Science, the Assessment Standards indicate content. There is a policy statement for each Learning Area that specifies content that needs to be included. This statement is known as the learning area statement (DoE, 2002(b)). Outcomes encourage local applications of content (DoE, 2006(a)). So the cohort of learners in this study who graduated from the outcomes-based grade 9 in 2005 had to enrol for grade 10 Physical Science in which content that had to be included was specified. This cohort missed out on the opportunity to follow a content based curriculum in earlier grades. Appendix L shows the content that has to be taught in grade 9 according to the Revised National Curriculum Statement (RNCS) – this was only introduced in 2006. The RNCS was later known as the National Curriculum Statement (NCS). Content was new to the grade 10 learners and OBE principles were new FET teachers. The transition from an outcomes-based system (in which content was left to the discretion of the teacher) to a system in which content was specified represented a potentially serious challenge for both educators and learners because it brought about discontinuity and inconsistency of the curriculum that educators and learners had become familiar with. This is in addition to the fact that transition from GET science to FET science is in itself a challenging transition.

5.2.2 Changes in time allocation

Time allocation has also been streamlined and has been more clearly specified from 2006. The time allocation for Natural Sciences in the GET phase has been increased from 12% in 2005 to 13% of the total contact time as from 2006 (DoE, 2006(a)). So learners in the sample have missed out on the advantages of the increased time allocations when they were in the GET phase.

5.2.3 Documentation required

The Gauteng Department of Education (GDE) noted that it would be very difficult to implement the NCS without the following core curriculum documents (DoE, 2006(a)):

- Learning Area Statement Document
- Teacher’s Guide for the Development of Learning Programmes (for each Learning Area)
- National Protocol on Assessment

I also noted that the Education Labour Relations Council had provided school A and school B with a file with all the main education policies. The policies are also available on the DoE website (www.education.gpg.gov.za).

5.2.4 Additional support

The South African government has launched an education portal (www.thutong.org.za) offering a range of curriculum and learner support material from GET to FET, professional development programmes for teachers and administration and management resources for schools. Teachers grappling with the challenges of introducing the national curriculum into classroom practice can download printable, quality-assured resource material that has been extensively cross-referenced against the new curriculum (Source: www.southafrica.info).

5.2.5 Assessment

Continuous assessment (CASS) is an assessment model used to determine a learner's achievement during the course of a grade, provide information that is used to support the learner's development and enable improvements to be made to the learning and teaching process (DoE, 2006(b)). CASS in grade R – 8 comprises of 100% of the assessment programme but only 75% of the total assessment programme in grade 9. A nationally set Common Task for Assessment (CTA) is used as the external summative assessment instrument at the end of grade 9. The CTA is moderated and approved by the General and Further Education and Training Quality Assurance Council (Umalusi) and contributes 25% of the final mark in grade 9 (DoE, 2006(b)). In grade 10 it is the other way round: CASS comprises of 25% of the final mark and the summative examination at the end of the year contributes 75% of the final mark (DoE, 2005(c)). This great difference in methods of assessment for grades 9 and 10 probably contributes to the large retention rate in grade 10, as discussed in the introduction of this thesis.

5.2.6 Matching GET science with FET Physical Science

The Natural Science grade 9 examination was in the form of a CTA that had to be completed within 5-hours, spread over a number of days. The CTA referred to here was based on Curriculum 2005 prior to the implementation of the RNCS. Table 5.1 is taken from the CTA and is an outline of the tasks upon which questions were set. It also outlines the skills that were examined (DoE, 2005(b)). Regarding prerequisite knowledge for grade 10, the DoE identified concepts that ought to be understood in order to cope with grade 10 Physical Science (DoE, 2002(a)). These concepts are listed in Table 5.2. However, comparing these concepts to the 2005 Natural Science grade 9 examinations (written by learners in this study when they were in grade 9) showed that the examination did not assess whether learners had an adequate basis to study grade 10 Physical Science.

Table 5.2 shows an analysis of scope and depth of coverage of the Curriculum 2005 and the NCS with regard to pre-requisite knowledge for Physical Science in FET**.** The table shows that the grade 9 learners in this study were not examined on Electricity, Heat and Work, Magnetism, nor Acids and Bases – the concepts that formed the core of pre-requisite knowledge for grade 10 Physical Science. Even the remaining two concepts that were covered, namely Waves and Chemical Reactions, were only dealt with in the context of managing malaria, and there was no in-depth coverage. This leads me to argue that the introduction of the NCS is a tacit admission by the DoE that Curriculum 2005 was creating large gaps of knowledge and was not preparing learners adequately for the transition. The document from the NCS workshop (Appendix L) was an attempt to close the glaring gap between Natural Science in the GET phase and Physical Science in grade 10 (FET). However, it does not address all topics, for example Magnetism and Waves are not covered.

Therefore, being able to pass the CTA did not mean that a learner had sufficient scientific knowledge to cope with the demands of grade 10 Physical Science. The 2005 grade 9 cohort that followed C2005 was at a clear disadvantage compared to later groups (from 2006) who followed the revised curriculum that re-introduced content in the GET phase. The grade 9 science content required by the RNCS is given in Appendix L. The RNCS was already available to teachers in 2006, which means that the 2005 cohort were indeed in a unique situation, missing out on better preparation for grade 10 Physical Science.

As content was left almost entirely to the discretion of the teacher and the school in the GET phase (2005), the teacher in grade 10 Physical Science (2006) was left with the challenge of finding out which concepts had been dealt with and which had not been covered.

Table 5.1 The Common Tasks for Assessment: grade 9 Natural Science (2005)

Programme Organiser: Managing Malaria		
TASK	**DESCRIPTION OF THE TASK**	**SKILLS**
1	**The classification of insects**	
	The classification of insects 1 & 2	Observing; following instructions; using knowledge to classify; recording data
	The classification of insects 3 & 4	Observing; following instructions; using knowledge to classify; recording data
2	**Malaria and the weather in South Africa**	
	The occurrence of malaria in South Africa	Accessing information; reasoning
	Malaria in the infected provinces	Drawing a graph to present data
	Investigating findings regarding malaria cases	Formulating a question; identifying processes; making suggestions
3	**The Anopheles Mosquito**	
	The life cycle of the Anopheles mosquito	Applying knowledge in Life and Living; using information to inform actions; generating options; assessing impacts on the environment
	The male and female Anopheles mosquitoes	Applying knowledge
4	**Malaria and its Control**	
	Mosquito repellents – their atoms and molecules	Applying knowledge in Matter & Materials
	Mosquito repellents – the phases of matter	Applying knowledge; making decisions; justifying decisions
5	**Malaria – a local solution**	
	Good for who?	Appreciating indigenous knowledge; identifying impacts on the environment; identifying impacts on socio-economic development; making decisions
	Let's let everyone know!	Communicating information; promoting ideas
6	**The sound of mosquitoes**	
	Making sounds	Doing practical investigations
	The science of sound	Interpreting; applying knowledge in Energy & Change
	More science of sound	Gathering and selecting relevant information; calculating wavelength and frequency; identifying variables
	Hearing sound	Applying knowledge

Table 5.2 Analysis of the scope and depth of concepts covered in the 2005 CTA.

Matching with concepts in the 2005 Grade 9 exam (Curriculum 2005)	**Concepts that should be understood in order to cope with grade 10 Physical Science (DoE, 2002(a))**	**Matching with grade 9 core knowledge and concepts (NCS)**
Covered ←	1. Waves →	Not covered
Covered	• Rectilinear propagation	Not covered
Covered	• Reflection	Not covered
Covered	• Refraction	Not covered
Not covered ←	2. Electricity →	Covered
Not covered	• Charge (atomic structure)	Covered
Not covered	• Current	Covered
Not covered	• Potential Difference	Covered
Not covered	• Resistance	Covered
Not covered	• Series and parallel connections	Covered
Not covered ←	3. Heat and Work →	Not covered
Not covered	• Work, energy and power	Not covered
Not covered	• Mechanical work (W = F x s)	Not covered
Not covered	• Particle model of matter	Covered
Not covered ←	4. Magnetism →	Not covered
Not covered	• Magnetic and non-magnetic material	Not covered
Not covered	• Polarity	Not covered
Not covered	• Forces of attraction and repulsion	Not covered
Not covered	• Magnetic field	Not covered
Covered ←	5. Chemical reactions →	Covered
Covered	• Atomic structure	Covered
Covered	• Element	Covered
Covered	• Molecule	Covered
Covered	• Compound	Covered
Covered	• Symbols and formulae	Covered
Covered	• Metals and non-metals	Covered
Covered	• Solubility	Covered
Covered	• Mixtures	Covered
Covered	• Solution	Covered
Covered	• Combustion	Covered
Covered		Covered
Not covered ←	6. Acids and Bases →	Covered
Not covered	• Reactions of acids with metals	Covered

5.3 CLASSROOM OBSERVATION

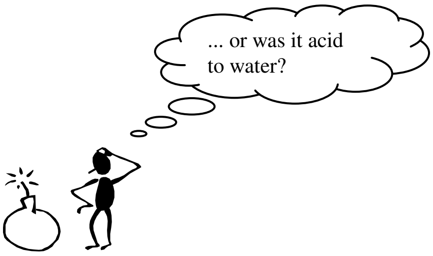


Figure 5.1 Poor teaching.

A total of 8 lessons (4 sets of twin lessons) were observed over four days. The first set of lessons (one each in the two grade 10 classes) was observed on the 15th of March 2006 and the rest on the 10th , 11th and 12th May 2006. By agreement with the teacher, I did not make a prior appointment for a particular lesson but instead showed up unannounced. This was to avoid having lessons specially prepared for the classroom observation. Table 5.3 gives an overview of the lessons observed.

In all the lessons observed, the teacher always stood in front. The sitting arrangement is represented in Figure 5.2.The learners sat in pairs on the desks that were arranged in rows. I was provided with a chair and sat as an unobtrusive observer in the last row of the class. The tape-recorder was placed in an open drawer of the teacher's table so that it would not distract the attention of learners. Two lessons on different topics were chosen for full transcription to best represented the problems that the learners encountered, both in terms of teaching strategies of the teacher and the learning style of learners. These two lessons were analysed according to general features of the lesson, questioning style of the teacher, classroom management, teacher directives/statements and the nature of learner engagement. These categories were used to focus on the description of the lessons and were adapted from the study by Manyatsi (1996).

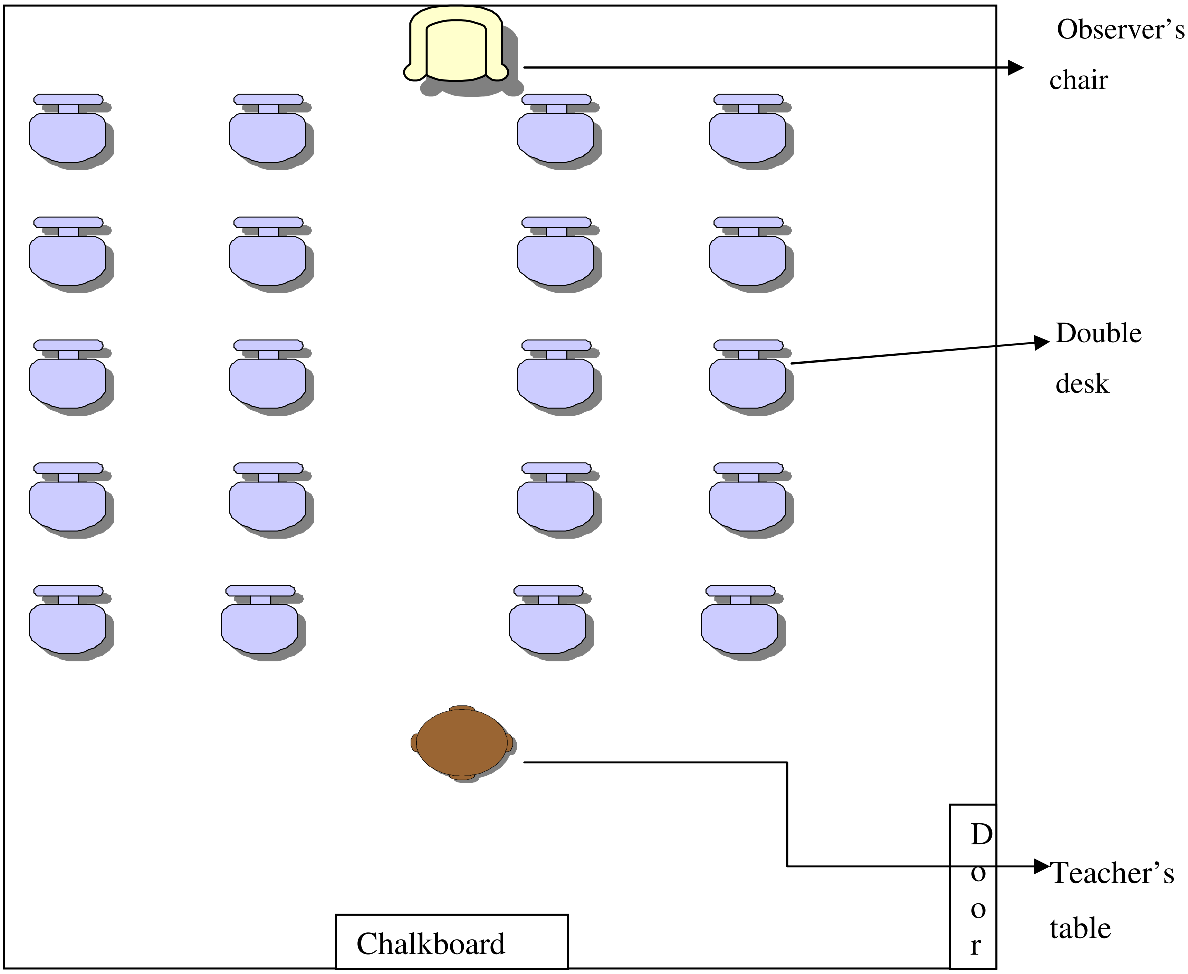


Figure 5.2 Sitting arrangement in the classroom (aerial view)

Appendix H and Appendix I show the full transcriptions of the two lessons. Those parts of the transcripts in parenthesis or italics are the researcher's insertions; either describing what could not be audio-taped or translating Sesotho into English in cases where the teacher was alternating between languages (i.e., alternating Sesotho and English in the lesson). Bold text denotes what the teacher either emphasized or wrote on the chalkboard. The lessons were coded numerically in the chronological order in which they were observed.

Table 5.3 Physical Science lessons observed

Lesson number	Date	Class	Lesson
1	15 March 2006	Grade 10A	Matter: mixtures – homogeneous and heterogeneous
2	15 March 2006	Grade 10B	Matter: mixtures – homogeneous and heterogeneous
3	10 May 2006	Grade 10A	Matter: elements, compounds
4	10 May 2006	Grade 10B	Matter: elements, compounds
5	11 May 2006	Grade 10A	Matter: atoms
6	11 May 2006	Grade 10B	Matter: atoms
7	12 May 2006	Grade 10A	Matter: metals and non-metals
8	12 May 2006	Grade 10B	Matter: metals and non-metals

5.3.1 Lesson 1 & Lesson 2

MATTER: mixtures – homogeneous and heterogeneous mixtures.

(i) General features:

The two grade 10 classes had an average of 40 learners each and the lessons took place in the classrooms. The teacher introduced the lesson by asking for the definition of matter. He went on to introduce the concepts elements, compounds, mixtures and suspension. It was a teacher-centred lesson in which the teacher did most of the talking. The only teaching aids used in the lesson were the chalk and chalkboard, on which the teacher jotted all the concepts discussed.

(ii) Questioning style:

The teacher asked oral questions from the beginning of the lesson to the end. These questions were mainly directed at the whole class and he rarely called learners by name to answer a question. The questions were classified into questions of recall, rhetoric and knowledge with understanding, with examples given below.

Recall: The teacher asked questions that required recall of facts i.e. memory questions.

Example:

Teacher: *Now, from previous classes I know that you have learned about what we call* ***matter****. What did we say* ***matter*** *was from previous classes?*

Student: *Matter is everything that occupies space and has mass.*

Rhetoric: The teacher asked leading questions that did not even need an answer.

Example:

Teacher: *Let's take examples of mixtures. Let's start with mixtures: If I take salt and mix it with water (writes on the board). I'm going to have a what? I am going to have a mixture! Not so?*

Students (in chorus): *Yes!*

Teacher: *And that mixture is called a clear mixture because water and salt can completely dissolve inside the what?*

Students (in chorus with the teacher): *Water!*

Knowledge with understanding:

There were questions that required knowledge with understanding.

Example:

Teacher: *Give me more examples of homogeneous mixtures that you see everyday.*

Student: *A coffee and hot water.*

(iii) Classroom management:

There was an occasion when there was dissatisfaction amongst learners after the teacher made what appeared to be an unconvincing argument.

Student: *In examples of homogeneous mixtures, do we always use water? Can you give an example without using water?*

Teacher: *Remember we have three phases of matter; it's either you can be able to mix liquid and solid or solid solid ... any example that will be able to be soluble ... that will combine completely ... remember homogeneous are those that can combine completely without eh ... in other words they are soluble ... they combine and they don't ... but homogeneous are those that cannot be separated easily ... yes my girl* (diverting attention to another student who had just raised her hand).

Student: *... how do you separate them?*

Teacher: *You can separate them through chemical means. Let's take an example of water and salt. If you heat the solution for a long time, the salt will remain inside the container.*

There were sustained hushed voices of dissatisfaction from the learners. Then there was a question from a student that was inaudible. The teacher ruled it irrelevant to the subject matter. He did not seem to be perturbed by the dissatisfaction and simply went on. The class became very noisy as they did class work. The teacher shouted at the top of his voice calling on the class to be quiet. It was after this reprimand that the class became quiet. He then went through the rows of desks to check on the learners' work.

(iv) Teacher's directives/statements:

The teacher gave both class work and homework to the learners:

Teacher: *Now; I have examples here; I want you together with your partner to separate them into homogeneous and heterogeneous*.

He wrote on the chalkboard: ink, milk, salt and water, tea, sand and water. The teacher then went around the class checking on learners as they went through the class work. The class was very rowdy. Towards the end of the period, he gave learners some homework: he asked them to look for five different products at home and identify their components from the labels, their % composition and then classify the components as solid, liquid or gas. Lastly they had to state if they were harmful or not. That was the end of the lesson.

(v) Nature of learner engagement:

There were no learner-initiated activities. Learners had to imagine the activities that the teacher spoke about: separation of mixtures (no practicals). According to Entwistle (1981), the learning style of learners affects and influences their response to different teaching styles. The difference between the teacher's teaching style and the learners' learning style leads to learning difficulties (Entwistle, 1981; Kempa & Ward, 1988). This ultimately leads to the learners not performing well when assessed (Manyatsi, 1996). This will also add to their transitional problems.

5.3.2 Lesson 7 & Lesson 8

MATTER: metals and non-metals.

(i) General features:

The two lessons took place in the classrooms. The teacher introduced the lesson by mentioning mercury as a metal. He went on to introduce the properties of metals and wrote them on the chalkboard. It was a teacher-centred lesson in which the teacher did most of the talking. The teaching aids used in the lesson were the Periodic Table, a sample of sodium, a sample of magnesium, chalk and chalkboard.

(ii) Questioning style:

The teacher only asked two oral questions throughout the lesson. These questions were mainly directed at the whole class and he never called learners by name to answer a question. Below is the classification of questions that the teacher asked:

> **Recall:** The teacher asked questions that required recall of facts i.e. memory questions.
>
> **Example:**
>
> **Teacher:** *Sodium in conjunction with chloride gives us something that we use everyday. What do you think that is?*
>
> **Student:** *Salt.*
>
> **Teacher:** *We use gold – what do we use gold for?*
>
> **Student:** *Jewellery.*
>
> **Open ended question:**
>
> There was an open ended question, namely:
>
> **Teacher:** *... what is the fun of learning these particular metals everyday?* (No answer from students)

(iii) Classroom management:

At one point the teacher gave learners two samples of metals, namely sodium and magnesium. These were immersed in small containers of paraffin. As the learners waited their turn to see the metals, the class became very rowdy and the teacher seemed to lose control. They only became silent when he spelt out what their homework was.

(iv) Teacher's directives/statements:

The teacher gave homework to the learners:

> **Teacher:** *Now, while you are looking at that, I have written some of the names here of the elements. You are going to do your investigation now over the weekend. I want it on Monday. You do it on the exam paper; we are going to file it for your portfolio.*
>
> *You are going to investigate ... what is sodium hydrogen carbonate; you are going to look at which product contains sodium hydrogen carbonate and what you use that product for. There are six of those that you are going to look at.*

(v) Nature of learner engagement:

There were no learner-initiated activities. Except for showing them the two metals, there was no hands-on activity in this theoretical lesson.

5.3.3 Summary

On the basis of the classroom observation tool in Appendix E (ELRC, 2003), I evaluated the teacher as follows (for both lessons 1 & 2 and 7 & 8):

Performance standard 1: Knowledge of curriculum and learning programmes

- He conveyed inaccurate and limited knowledge of the subject (e.g. boiling is a physical change not chemical).
- He displayed no skill of creating enjoyable learning experiences for learners (did not facilitate practical experience – no experiments or demonstrations).
- There was little or no evidence of goal-setting to achieve curriculum outcomes (he did not indicate the learning outcomes as prescribed in the NCS).
- He did make some attempt to interpret the learning programmes for the benefit of learners (he did teach the relevant content).

Performance standard 2: Lesson planning, preparation and presentation

- Lesson planning was not fully on a professional standard (he did not follow guidelines for lesson planning).
- Lesson was not presented clearly (learners had to imagine the activities that the teacher spoke about: separation of mixtures (no practicals).
- Evidence of essential records of planning and learner progress was available (learner portfolios were kept).
- Learners were not involved in lessons in a way that supports their needs and development of their skills and knowledge (it was a teacher-centred discussion in which the teacher did most of the talking).

On a number of occasions, while listening to the teacher in class, I was tempted to stand up and correct him. But then I reminded myself that I had undertaken to be an unobtrusive observer. I also reminded myself of the ethics statement that I made, so I could not even report him to the principal. I had to sit throughout the lesson unable to intervene, which was a very uncomfortable experience!

The teacher did not follow the guidelines for lesson planning (refer to Appendix F). His lesson plans did not indicate the learning outcomes as prescribed in the NCS. He did not seem to be aware of new curriculum changes and approaches. Maybe it was the case of *The more things change, the more they remain the same (Plus ça change, plus c'est la même chose*) attributed to Alphonse Karr (1808 – 1890), French journalist, novelist. Les Guepes (Paris, Jan. 31, 1849) from http://www.bartleby.com/66/88/32088.html (retrieved 18 May 2006).

5.4 INTERVIEWS

To understand learners' problem solving strategies, eight of the Physical Science learners in grade 12 were selected to participate in semi-structured interviews following up on the diagnostic test they had just written. The learners were selected on the basis of performance in the grade 11 examination. The top four students in the grade 11 Physical Science examination were selected for interview and labelled as high achievers and the lowest scoring four students in the same grade 11 examination were selected and labelled as low achievers.

The learners were also categorized as post-positivist-oriented or empiricist-aligned based on their scores on the NOS survey; the mean was used as the cut-off point in the classification. The students selected on the basis of low examination achievement were those whose reference numbers (V_1's) were 11, 13, 33 and 49 (refer to Table 4.13(a)). These four learners were also labelled as empiricists because of their low scores in the NOS questionnaire, and were all given pseudonyms that had initials of L.E. (Low achiever and Empiricist). For example, Lenah Edwards would be a girl who was a Low achiever and Empiricist-aligned. The high achievers (top four) according to Table 4.13(a) were those with reference numbers (V_1's) 17, 18, 28 and 43, two of whom happened to be post-positivist oriented while the other two were empiricist-aligned. In this case the pseudonyms had initials of H.P. (High achiever and Post-positivist oriented) or as H.E (High achiever and Empiricist-aligned). For example, Hazel Planck would be a girl who was a High achiever and Post-positivist oriented while Humphrey Edwards would be a boy who was a High achiever and Empiricist-aligned. Table 5.4 gives details of scores and the pseudonyms used for the eight interviewees. The table shows the examination marks as percentages and the NSKS scores out of 240.

Table 5.4 Scores of the interviewees in the gr. 11 examination and the NOS questionnaire

V_1	Gender	Exam marks (%)	NSKS score (max 240)	Pseudo-name
11	F	20	150	Lenah Edwards
13	F	24	159	Linda Epson
33	F	30	160	Louisa Ericsson
49	F	30	149	Liza Eddington
18	M	50	154	Henry Els
17	M	50	155	Humphrey Edwards
28	M	51	175	Howard Prins
43	F	60	167	Hazel Planck

Interviews were transcribed (Appendix J) and also coded to summarise responses. Table 5.5 shows the coding that was used to summarise the interviews.

Table 5.5 Response codes used for interviews.

Description	+1	0	-1
Physical Science is a favourite subject	Yes	Neutral	No
Career choice in the Physical Sciences	Yes	Neutral	No
Interest in the Physical Science increasing	Yes	Neutral	No
Teacher-student relationship is closer	Yes	Neutral	No
Teaching strategies meeting expectations	Yes	Neutral	No
Border crossing is smooth	Smooth	Managed	Hazardous
Avogadro's hypothesis	Conceptual understanding	Misconception/ Incomplete concept	No concept
Mole concept	Conceptual understanding	Misconception/ Incomplete concept	No concept

5.4.1 Sample interview

Table 5.6 traces a pilot interview with a student chosen randomly. He happened to be classified as a High achiever and Post-positivist oriented. The purpose of the pilot interview was to gauge the time it would take to interview one subject. The interviewee was named Herman Pattington. The interview took place on the same day that the rest of the interviews were conducted. The interview analysis using the above-mentioned coding is also given.

Table 5.6 Pilot interview with Herman Pattington

No	STATEMENT	Code
1	I: Good afternoon …. Ehm, what is your favourite subject in the FET phase?	
2	S: Is not only one, Life Sciences, Physical Sciences and Mathematics …	
3	I: … but what is your most favourite one, the one that you like most?	
4	S: I choose Maths, … Mathematics	-1
5	I: Mathematics?	
6	S: Yes	
7	I: OK … will you give me reasons why?	
8	S: I have always been good in Mathematics. Following my situation at home…. I have always been good at Maths … It hasn't been that difficult.	
9	I: … what career would you like to follow?	
10	S: I would like to pursue a career in actuarial sciences …it deals with statistics and … yeah	-1
11	I: Ok …why would you choose actuarial sciences?	
12	S: 'cause, it mainly involves Mathematics of which is the subject I really like … I feel like I will be able to do the job well.	
13	I: Ehm …Is your interest in science declining, increasing or remaining the same as you move from the GET phase to the FET phase?	
14	S: OK, I think it is increasing, because in the GET phase, it was more on the general perspective, but then when you get to the FET it's a bit different, … maybe you might say a bit harder but then … it gives us more detail and … I think it is increasing	+1
15	I: How do you compare your relationship with your science teachers in grades 7,8 and 9 with your relationship with your science teachers in grades 10,11 and 12?	
16	S: My science teachers in grades 7,8 and 9 … eh … I might say they were … not really putting that much effort into teaching us … there was like basics … so I don't think it's the same as the ones in the FET phase but then … there isn't much difference according to me.	0
17	I: Is the way science taught in the FET phase meeting your expectations … is the way science taught in grades 10, 11 and 12 is that what you expected?	
18	S: No, it's not really what I expected. I expected it to be a bit more … you might say … specific and not like on a general … like they are doing now	-1
19	I: In your own words, how do you describe the transition from the GET to the FET phase focusing on the transition from Natural Science to Physical Science?	
20	S: As I said … eh …Natural Science was a bit more broad, when we came to Physical Science and Biological Sciences/ Life Science, I think that … my interest is more like in Life Sciences, so I see it as a change in which you see what better subject suits you best	0

No	STATEMENT	
21	I: Now we come to the diagnostic test that I gave you; the test was on the mole concept. In the first one I said to you "which one of these three sets best shows 1 mole of tin, 1 mole of magnesium and 1 mole of sulphur in each tube" and you chose set 1. Can you explain how you arrived at set 1. Why do you say set 1.	
22	S: If we are calculating for the molar value, we are using the volume of any element, so what I did was use the formula of V = oh, sorry, n = V/Vm of which … eh .. since set 1 has the same volume, eh … the molar volume is $22.44dm^3$ eh… I saw it as the same thing … I arrived at the same conclusion.	0
23	I: In other words, when you see 1 mole of tin or 1mole of magnesium or 1 mole of sulphur, what comes to your mind is the volume …(*interruption*)	
24	S: Not only that, but … I think we have two ways of calculating the number of moles, which is the … m/M_r … so, since I do not have the exact figures of the mass of these two … magnesium or sulphur, I could not arrive at the conclusion that my answer is correct or …	0
25	I: Perhaps I should also ask you: what do you understand by a mole?	
26	S: A mole … I think it is a value that is put in an element … since elements are very small, so a mole is being used to … as a relative number to give us some value of say a certain element.	
27	I: Thank you; let's come to the second question: In the second question: you chose … you said all of them … all these containers contain one mole …can you give reasons please!	
28	S: I said all containers contain one mole … because when you use the formula n = V/V_m, I get one mole for all the containers … since the volume of the containers is the same and the constant molar volume is the same, so I arrived at the same conclusion for all the containers	
29	I: Thank you!	

5.4.2 Favourite subject

A typical question that was asked was "What is your favourite subject in the FET phase" followed by " will you give reasons why?"

It is interesting to note that seven of the eight interviewees did not choose Physical Science as their favourite subject. Three gave Life Sciences as a favourite subject and one gave Life Orientation as a favourite subject. Their responses were:

> *Liza Eddington: … it has to be Life Science… because… eh …my career… the career that I'm following has to do with the things that we are told in Life Sciences … meaning that my career … I want to be a doctor … so I think that my career depends on it mostly*

Linda Epson: My favourite subject in the FET phase is Life Science
Interviewer: Can you tell me why?

Linda Epson: Because in Life Science we learn more about human bodies … it teaches us about things that we don't know.

Louisa Ericsson: Biology is kind of interesting to me … I want to pursue a career that falls under Biology … which is gynaecology … because I'm more interested in knowing a woman's body; so, I do like Biology

Lena Edwards: Life Orientation
Interviewer: Explain why Life Orientation
Lena Edwards: It deals with exercising and I like to exercise

It is also interesting to note that all the low achievers have indicated Life Sciences and Life Orientation as favourite subjects. These subjects deal with everyday issues that are not abstract and do not require a high level of conceptual understanding. This could be the reason why low achievers prefer them over Physical Science and Mathematics.

Two interviewees preferred Mathematics to Physical Science. These learners were high achievers and cited passion as the reason for their preference as well as the fact that in Mathematics one does not have to memorize notes. Other factors such as poor teaching and lack of laboratory resources - as noted under classroom observation - could also have counted against Physical Science as a preferred subject:

Henry Els: It's Mathematics
Interviewer: Why Mathematics
Henry Els: Actually I have a passion for .. like playing with numbers and all that

Hazel Planck: My favourite subject is Mathematics because in Mathematics we do more with figures … and you have to calculate … it's not all about cramming the notes you are given … you have to know your subject and you have to practice

In Chapter 4, I found that there was no correlation between interest and achievement in class. It is therefore not surprising that high achievers in Physical Science (Henry Els, Hazel Planck and Humphrey Edwards) named other subjects as their favourites. For example, the favourite subject for Humphrey Edwards was English:

> *Humphrey Edwards: It's English because… actually I like novels … I like books much … we get to do books and in those books we get life skills … like for instance the book we are doing Maru – it takes you through a journey of somebody, then you get to learn such things.*

Howard Prins was the only high achiever with a great interest in Physical Science:

> *Howard Prins: Science*
> *Interviewer: Will you explain why science?*
> *Howard Prins: Because … in science … I'm very good in science but again it's a subject that I found very interesting and which I wanted to pursue later on in future*

In summary:

- Most learners did not choose Physical Science as their favourite subject, reasons ranging from simply being interested in their subjects of choice to lack of experiments in chemistry.
- The way one experiences transition from the GET phase to the FET phase can influence one's preference for the subject.
- It seems that there is a general lack of interest in Physical Science with the exception of one high achiever.

5.4.3 Career choice

A typical question asked was "What career would you like to follow?" followed by "Will you explain why?"

The responses were mostly in line with their favourite subjects. Again, the low achievers, indicated a career choice in the Life Sciences or community work (e.g. serving in the police):

Linda Epson: Metro police.

Interviewer: Can you give me the reason why?

Linda Epson: If you look at most people working in the Metro police, there are no females … it's mainly males. I like the Metro police a lot because…it teaches people a lot: if you are a woman, you are a woman

Lena Edwards: I would like to follow nursing

Interviewer: Why would you like to follow nursing?

Lena Edwards: I like to deal with health problems … I like to help sick people

Liza Eddington: … it has to be Life Science… because… eh …my career… the career that I'm following has to do with the things that we are told in Life Sciences … meaning that my career … I want to be a doctor … so I think that my career depends on it mostly

Louisa Ericsson: Biology is kind of interesting to me … I want to pursue a career that falls under Biology … which is gynaecology … because I'm more interested in knowing a woman's body; so, I do like Biology

All the high achievers chose careers in the hard sciences: engineering, computer and actuarial sciences. Both computer sciences and actuarial sciences need Mathematics as a prerequisite, that is a subject which both Henry and Hazel indicated to be their favourite.

Henry Els: I would like to follow computer sciences … since I found that …I have love for computers …then I decided that … let me rather choose a career which involves computers a lot.

Hazel Planck: I'd like to be an actuarial scientist, because as an actuarial scientist … it deals with figures and statistics, and you also have to engage with the community; get to know more about the … where the country is going in terms of its commercial/ financial status.

It was not surprising that Howard, whose favourite subject was Physical Science, chose mining engineering as a career.

> *Howard Prins: Mining engineering*
> *Interviewer: Will you explain why mining engineering?*
> *Howard Prins: Mining engineering is a very interesting field. In mining you deal with extraction of metals. The company which uses metals is the company that I want to work for … I'm interested with working with the elements of the Periodic Table*

Although Humphrey indicated English as his favourite subject, when he was asked about his attitude to science during transition, he did indicate that his interest in science was increasing as he was moving from the Natural Sciences to the Physical Science. It is therefore not surprising that he chose a career in the metallurgical science:

> *Humphrey Edwards: Metallurgical science …in fact it's between metallurgical science and electrical science but I think I love metallurgy most.*

In summary:

- The responses were mostly in line with their favourite subjects. Again, the low achievers whose favourite subject is Life Sciences indicated a career choice in the Life Sciences or community work (e.g. serving in the police).
- All the high achievers chose careers in the hard sciences: engineering, computer and actuarial sciences
- It seems that achievement in science does influence the career choice.

5.4.4 Attitude to science during transition

The typical question here was: "Is your interest in science declining, increasing or remaining the same as you moved from the GET phase to the FET phase".

All the low achievers indicated a declining interest in science as they moved from the GET phase to the FET phase. It was disturbing to note that this trend was also seen amongst some high achievers. The majority of learners were thus indicating a decline in interest. All the girls indicated a decline of interest and that includes the high achieving Hazel.

Lena Edwards: Decreasing … because I see that when I came from primary school to secondary school, the primary school and the high school is not the same; at high school it is the place where you have to work hard and know what you want in life.

Louisa Ericsson: It is declining, because in … what was the phase?… the GET phase ... it was more simpler than this phase I'm in now. I think it is also because what we did then is not the same as what we are presently doing because of the change in curriculum.

Linda Epson: No, it's decreasing, because in grade 9 it was better than this year, 'cause it's so difficult for me

Liza Eddington: Actually at the moment it is decreasing, but then I know that I will pull up again, but at the moment it is decreasing
Interviewer: What would you say is the reason?
Liza Eddington: I think that the things I was told before, were not that hard than now… things are changing and getting more difficult and I'm getting used to that… and the changing of teachers … last year we were taught by teacher X now this year we are taught … they have changed teachers, so I was used to teacher X from grade 10 and 11 but now they have changed him and so I think that is my problem.

Hazel Planck: My interest in science is declining because in the FET phase it's more complicated. I think the work is more and you have to memorise all these terms. It's more work and the chemistry part … I like the chemistry part as I was doing grade 9 and grade 8 but as I got to grade 10 it was more difficult because there was a bit of change in the way it was taught and the way I understood it; and the other thing is that we don't have laboratory so we have to read the experiment from the text-book and cram it

Henry Els: It's declining
Interviewer: Can you give me reasons why?

Henry Els: Basically, from the GET section… the teachers there … they were like … trying to explain most of the stuff … and we didn't like expect the way we are being taught now

An increase in interest was only found in boys. This was also in line with the statistical inference in Chapter 4 that there is a tendency to be more interested in Physical Science amongst boys as they moved from grade 9 to grade 10. It must be noted, however, that boys were a minority in the sample:

Humphrey Edwards: I think it is increasing because from grade 10 to grade 12 we were introduced into new things like for instance momentum and the rates of reactions … you get to know how something happened that I did not understand how they occurred … but now through science I understand why is it that all things go down and not up … so I think being introduced to new things … things that are related to everyday life … I think it is increasing.

Howard Prins: It's increasing since I find it more interesting even though it's hard sometimes but I try to meet the standards of science.

Many studies on the subject of science have found that attitudes generally become less positive as students progress through the schooling system. Baurnert (1995) used a longitudinal study of 9400 year 7 learners in Germany to confirm his assumption that interest in all school subjects declines as adolescents become more involved in developing a social identity. Studies in the USA and Australia, show that positive attitudes towards science decrease throughout the school years, with the most dramatic change occurring during the transition from primary to the secondary school system (Baird & Penna, 1992).

In summary:

- The majority of learners indicated a decline in interest as they moved from the GET science to the Physical Science in FET
- All the girls indicated a decline in interest in Physical Science as they moved from the GET to the FET phase
- Two boys (both high achievers) indicated an increase in interest.

5.4.5 Teacher-student relationship over the transition period

A typical question was: "How do you compare your relationship with your science teachers in grades 7, 8 and 9 with your relationship with your science teachers in grades 10, 11 and 12?"

There was a mixed reaction to this question. Some did not see any difference or did not categorise the relationship as close or distant:

Lena Edwards: I think they are the same, I don't see any difference

Louisa Ericsson: There is a difference … the teachers in grade 10 were different and are not the same as the teacher I have now … they have different teaching strategies

But the majority lamented the loss of a closer relationship with their teachers in the GET phase:

Liza Eddington: In grade 7 to 9 it was very good, it was very good because as I said before I was very good in those subjects but now it's good but not that good. It's not good because of what I've just said.

Henry Els: It's different … because …from the early grades .. teachers try to make us have more love for science rather than the ones we have right now. In the FET section, they come to class, teach you and the other work is for you to do

Howard Prins: Now the science teachers are a bit harsh about the work and in grade 7 grade 6, they were just teaching you everything, but now they tell you: the reason you are doing science is because you wanna be someone. So they teach you in such a way that you become interested more and more in science.

Humphrey Edwards: I think from grade 10 downwards, the relationship was kind of a parent and child .. because we were not .. they still took us as children .. . like they had to guide us … talk to us … understand us but since from grade 10 to grade 12 *sometimes we were taught by an HOD … he's got a lot of duties so actually he just comes to teach you … you only have time to talk in class because they teach different classes and some are deputy principals they have to do some things … so it's kind of a distant relationship*

It seemed that most learners had closer relations with their GET teachers, similar to relations in primary school. The caring culture of the primary school has little in common with the more academically oriented, fragmented and competitive climate of the secondary school (Eyers, 1992). Similar problems are reported in Canada and the USA by Hargreaves and Earl (1994)

In summary:

- Most learners lament the loss of a closer teacher-student relationship in the GET phase
- A close teacher-student relationship would help to facilitate a smooth transition.

5.4.6 Teaching strategies over the transition period

The question was phrased as follows: "Is the way science taught in the FET phase meeting your expectations?

The majority of learners expressed disappointment at the lack of opportunities to do experiments in senior grades:

Lenah Edwards: No.

Linda Epson: No. In grade 9 lessons were easier to follow, but in grades 10, 11 and 12 it's becoming more difficult.

Henry Els: No, it's not
Interviewer: Can you explain?

Henry Els: When you have to do certain parts, especially in chemistry … that's where you have to do experiments .. so you find out that the school does not have enough material to help us out .. so you end up doing the experiment as part of theory.

Hazel Planck: No, it is not, because when I was in grade 8 and 9 we did a lot of experiments … science was more of a practical subject but as we get to grade 10 we get stories like a … things that we have to do like experiments … they are expensive and we can no longer do them …so science is now more like …you have to cram and … know terms by heart without actually seeing the things you are talking about.

Howard Prins: No it's not, because most of the time we only do theory and we don't normally use the labs, especially in chemistry for practical so you can understand more if you do practical but when you only do theory sometimes it's hard to understand.

The learners experienced disappointment similar to that reported by Baird et al., (1990), who noted the disappointment of learners who were beginning secondary school. The learners expressed their disappointment at the lack of activities, listening to lectures and the irrelevant topics (Baird, 1994).

In summary:

- Most learners indicated that the teacher's teaching strategies did not meet their expectations. They were hoping that to deal effectively with the challenges of the new environment (FET), they would be equipped with the necessary skills. They were disappointed to find that there were no chemistry experiments being conducted in the FET.

5.4.7 Transition – how they feel about it

A typical question here was: "In your own words, how do you describe the transition (movement) from the GET to the FET phase focusing on the transition from Natural Science to Physical Science?"

The majority of learners expressed the view that the transition was not smooth , but difficult:

> *Henry Els: I would say it's more like going to university but you're still at school … in grade 9 we were told … grade 9 is like grade 12… the way we are being assessed …so… moving to grade 10 … was more like you were doing your first year … doing your first year in matric.*

> *Liza Eddington: It's very different, it's very different, because… things are now changing and being more difficult because … in grade 7, 8 and 9 things were simple then … you were learning simple stuff and you would understand easily, but in grade 10, 11, 12 theirs were a bit difficult but then … I think that's the way things should be, you know.*

> *Hazel Planck: Well … when you go to the FET phase … there is more work … it is more difficult. I think in the lower grades they prepared us for is change because we used to write assignments and we did a lot of essays - maybe about a page but when we get to FET we have to write about three pages or four pages … it is more work … but it is in a good way because in the GET we were prepared for that*

> *Howard Prins :Natural Science was just basic things, something like general knowledge but now when you come to FET there are laws … Newton's Laws and everything. Before you do anything in science you have to understand the concepts first. So, it's hard yeah, it's hard.*

> *Humphrey Edwards: I think the transition was big, because the way I understand it, Natural Science was the combination of Biology and Physics so in the FET phase like this they put them into two. In Physics we use formulas and everything and in Natural Science we deal with things like volcano … we focused more in the theoretical part. But now in the FET you have to know your theory together with your calculations and you get to be told new things that you didn't know, that you were not taught and some of the things are abandoned from grade 7 and in grade 10 you do new things.*

Lena Edwards: In grade 9, 10, 11 is not the same as in grade 12 because in grade 12 … I think that is the grade that is the most difficult. And we have to work hard so that you can achieve your dreams or goals

Louisa Ericsson: In Natural Science things were much simpler. Right now we do many things that we did not do in Natural Science.

Linda Epson: I think Physical Science is difficult

In summary:

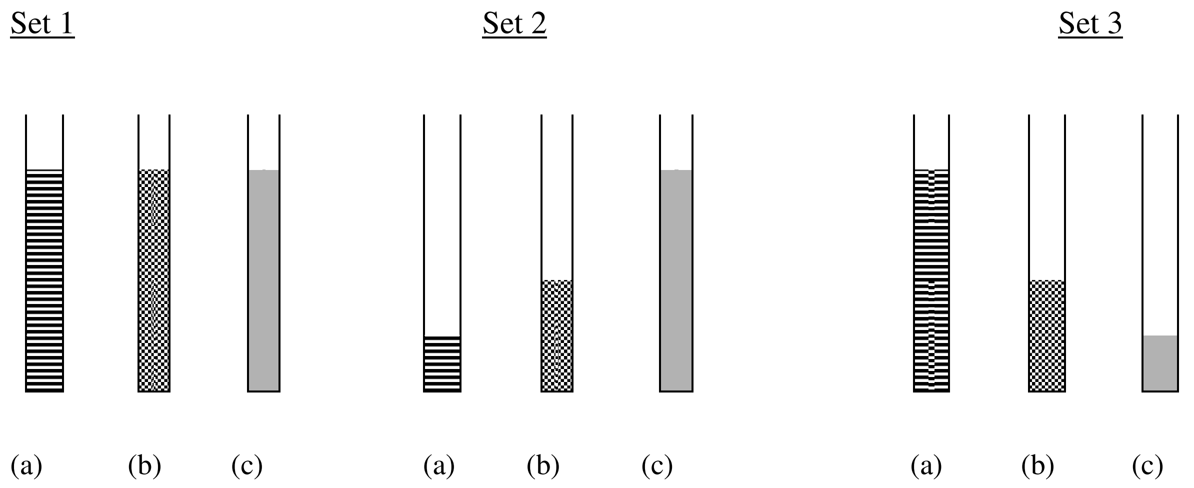
Most learners felt that the transition from the GET phase to the FET phase was a difficult transition. Using the cross-border metaphor in the theoretical framework, one can describe the transition as hazardous (Cobern & Aikenhead, 1998).

5.4.8 Conceptual understanding – learning strategies

The diagnostic test that was given to the subjects was meant to assess their conceptual understanding that was essential for negotiating transition. The interview question here was intended to help to answer research question 3: How can the learners' strategies and approaches for negotiating the transition be understood and explained?

The first question was asked as follows:

Which of these three sets best shows 1 mole of tin, 1 mole of magnesium and 1 mole of sulphur in each tube?



(a) - tin
(b) - magnesium
(c) - sulphur

key: Set 1 - equal volumes
Set 2 - equal masses
Set 3 - equal number of atoms

The interviewee was given his/her answer sheet to reflect on the answer and then asked to justify it.

Most learners chose set 1, probably because the textbook emphasizes that equal volumes of gases are a measure of equal numbers of particles, based on Avogadro's hypothesis. The students totally disregarded the fact that tin, magnesium and sulphur were all solids and simply applied Avogadro’s hypothesis. Even a common solid like tin does not seem to give a clue:

> *Humphrey Edwards: I chose set 1 because … first of all we are just given the number of moles which is 1and we are not given the quantity of the volume so I decided to make the volume of each container to be 1, then I took the formula n = V/Vr Vr which is the S.T.P … I took the volume of each container to be equal to that of the S.T.P then I used the formula n = V/Vr which then I got 1… and because now the moles of tin, mole of magnesium and sulphur were each taken to be one … so then I did one calculation and concluded that all of them in set 1 must be 1 because I assumed that … the volume of each container must be equal to that of the S.T.P. That’s the reason I chose set 1*

Louisa Ericsson: I chose set 1 because I realised that the molecules were equal so I thought that they had 1 molecule

Of course this assumption is wrong as there are no gases involved here. Some said they have never even heard of Avogadro's hypothesis:

Interviewer: Have you ever heard of Avogadro's number?
Lenah Edwards: No
Interviewer: Have you ever heard of Avogadro's hypothesis?
Lenah Edwards: No

Liza Eddington: I chose set 2 because … Mg is higher than S or Sn, their masses are equal but their volumes … I thought they were not equal

Linda Epson: I chose set 2 because I saw .. eh.. equal volume, equal mass and equal number of atoms. Then I think it was the right answer.

Henry Els: Choosing set 2 … I had confusion dealing with chemistry. ..if they are having equal masses … then the number of moles must be equal … rather than sticking to: if they have equal volumes … equal volumes does not mean that they will always have equal number of moles … because you may find that one may be a solid while the other one is a gas.

It was only the two high performing post positivist-oriented learners who chose the correct answer, namely set 3. They, however, did not give satisfactory motivation:

Hazel Planck: The reason why I chose set 3 …I looked at the beakers in terms of the volumes … the number of atoms which are in the beakers … so I looked at the beakers and then I compared set 1,2 and 3 … I looked at them in sequence …in set one they are full and they decrease again in set 2 and set 3 again … the beaker is still the same while the 3 beakers decreased
Howard Prins: Because in set 3 they said they are equal atoms – and the question said: in which of the containers had one mole so if ever the container has equal … the

atoms are equal … when they are about to bond … it means there was one mole, one mole one mole in each before the reaction.

Interviewer: Before which reaction?

Howard Prins: It's tin, magnesium and sulphur, so in each of the sets they are … ok, this one is one mole one mole one mole, if ever you are doing a reaction, let's say nitrogen and hydrogen then you use one mole one mole to give you the forward reaction

It was clear that learners had a serious problem with understanding the concept of the mole. The low achieving empiricist-aligned learners did not seem to have an idea at all. When asked what they understood by a mole, they responded as follows:

> *Liza Eddington: Actually nothing … nothing*

> *Linda Epson: I understand that a mole … is something that … they use it mostly in Physical Science … maybe to describe … I think sulphur, magnesium … I think they are using chemical or electrical chemistry*

The high achievers (both post positivist-oriented and empiricist-aligned) showed they had misconceptions or incomplete conceptions of the mole. They described a mole as either a number or amount (quantity):

> *Howard Prins: I think it's the number of atoms which are needed for a particular reaction to happen*

> *Henry Els: It's a certain quantity of a substance … whereby if you do an experiment … you have to consider how much you put in. The other way of putting it …it's like dealing with concentrations .. but …by moles we deal with … the quantity*

Humphrey was the closest to describing the mole as a unit for amount of substance, but poor English got the better of him:

> *Humphrey Edwards: A mole is …we calculate things in masses like for instance we've got kilograms, we've got grams and we've got milligrams but*

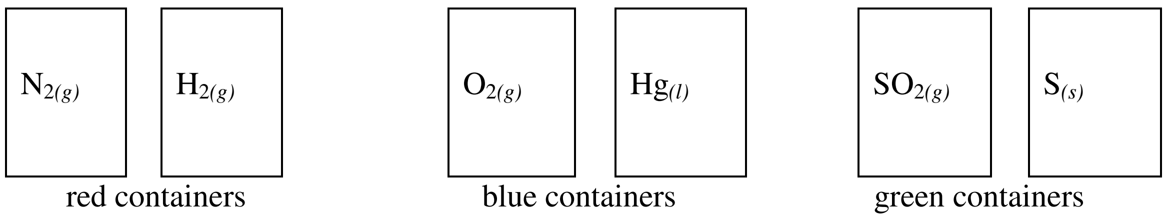
in science in most cases we experiment using smaller quantities … we take grams and convert it to molar … in a form of moles, so that it cannot be in that large number like kilograms

In the pilot interview, the interviewee (High achiever/Post-positivist) showed rote application of concepts and algorithms and described the mole in terms of volume. When he was asked to justify the choice of set 1 in the first question he responded as follows:

Herman Pattington: If we are calculating for the molar value, we are using the volume of any element, so what I did was use the formular of V = oh, sorry, n = V/Vm of which … eh .. since set 1 has the same volume, eh … the molar volume is 22.44dm^{3} *eh… I saw it as the same thing … I arrived at the same conclusion.*

The next question was:

Each container represents a volume of 22,4*l* at S.T.P. In which of the three pairs of containers, if any, is there one mole in each container?



Learners were asked to give reasons for their choice as well as for not choosing others.

Once again, the subject was allowed to have a look into his/her answer sheet and asked to justify his/her answer. Some of those who correctly chose red containers provided incorrect motivation for their choice. The similarity in the number of atoms for each of the gas molecules in the red containers could have made it a plausible option for these empiricist-aligned subjects:

Liza Eddington: I chose red containers because I thought that the … their volume, they were having the same volume
Interviewer: All of them have the same volume … 22.4 dm^3 at S.T.P
Liza Eddington: Oh, yeah! … I thought that … because nitrogen has 2 … 2 nitrogen and 2 hydrogen, so they will have 1 mole in each

Henry Els: I chose it (red containers) because … when in class we were doing .. balancing the equations … we were told that … in front of an element …the number in front represents … the coefficient .. represents the number of moles.. then .. if nitrogen gas and hydrogen gas … that would mean that … they have equal number of moles … meaning that … each one has one compared to the other containers.

The high achieving post positivist-oriented Hazel was correct but indicated that she was not sure (showed 0% level of confidence) citing poor teaching or lack of teaching in chemistry as the reason.

Hazel Planck: I chose red containers because … both elements are gases while in the blue containers you've got a liquid and you also have a solid (pointing to sulphur in the green containers). *It's just because of the gases*
Interviewer: I see that you have 0% level of confidence – are you sure that you are correct?
Hazel Planck: No, I am not sure that I'm correct – I just used common sense because here at school we are not actually taught … chemistry …. we do a lot of the Physics part …. the calculations …. Not the chemistry part because it includes experiments

When asked why he said all containers had one mole of each substance, Herman Pattington a post positivist-oriented subject, replied as follows:

Herman Pattington: I said all containers contain one mole … because when you use the formula $n = V/V_m$, I get one mole for all the containers … since the volume of the containers is the same and the constant molar volume is the same, so I arrived at the same conclusion for all the containers

This is consistent with the misconception that Avogadro's hypothesis applies to all phases of matter. While the post positivist-aligned subjects seemed to labour under some misconceptions, the empiricist-oriented subjects had no conception of Avogadro's hypothesis as shown below:

> *Humphrey Edwards: I chose the green container … I used the oxidation theorem … I used the valency numbers … I tried to find the oxidation number for oxygen in each container … then I found the oxidation number of SO_2 to be 2,5 and then again I found the … I found it to be 2,5 in both cases … then I said it is the green container because the number of moles in each container is the same … because the ratio of oxygen in each container is the same … so I concluded that the number of moles is the same both in the … due to the calculation that I have made.*

> *Louisa Ericsson: Why I chose blue containers? Because both elements have a bigger number of mass … they contain less number of atoms … I was using a Periodic Table when I answered this question … I found that one container had a gas and the other one consisted of a liquid. That's why.*

> *Lenah Edwards: I was thinking that I added the red container with the green container, they will remain the same as the blue colour container*

In summary:

- Faced with what seemed to be difficult conceptual problems, learners resorted to rote application of concepts and algorithms and sometimes guessing.
- They showed misconceptions and incomplete conceptions of the mole and Avogadro's hypothesis.

5.4.9 Summary of interview responses

Table 5.7 summarises the interview responses by all the eight interviewees. This table must be read in conjunction with Table 5.5 and Appendix J. The following list summarizes results the interview responses:

- Positive attitudes towards science declined during transition from GET (Natural Science) to FET (Physical Science).
- The negative attitudes towards science during transition seemed to affect career choices. Most learners chose careers outside the Physical Sciences.
- Lack of practical work, particularly in Chemistry, seemed to make learners less interested in Physical Science. Most of them did not choose Physical Science as their favourite subject.
- On the question of teacher-student relationships, the majority lamented the loss of a closer relationship with their Natural Science teachers in the GET phase.
- On the question of their expectations of teaching strategies the majority of learners expressed disappointment at the lack of opportunities to do experiments in the FET phase, particularly chemistry experiments in Physical Science.
- The majority of learners expressed the view that the transition was not smooth – in fact it was difficult. Using the cross-border metaphor, one can describe this transition as hazardous (Cobern & Aikenhead, 1998).
- Interviews confirmed a lack of conceptual understanding revealed by the diagnostic test. Learners' explanations indicated rote learning and algorithmic problem solving.

Table 5.7: Summary of interview responses

Description	Herman Pattington	Henry Els	Hazel Planck	Howard Prins	Humphrey Edwards	Louisa Ericsson	Lenah Edwards	Liza Eddington	Linda Epson
Physical Science is a favourite subject	-1	-1	-1	+1	-1	-1	-1	-1	-1
Career choice in the Physical Sciences	-1	-1	-1	+1	+1	-1	-1	-1	-1
Interest in the Physical Science increasing	+1	-1	-1	+1	+1	-1	-1	-1	-1
Teacher-student relationship is closer	0	-1	+1	-1	-1	0	0	-1	+1
Teaching strategies meeting expectations	-1	-1	-1	-1	+1	+1	-1	+1	-1
Border crossing is smooth	0	-1	-1	-1	-1	-1	-1	-1	-1
Avogadro's hypothesis	0	0	+1	-1	-1	-1	-1	-1	-1
Mole concept	0	0	-1	0	0	-1	-1	-1	-1

5.5 CHAPTER SUMMARY

Document analysis

In 2005 when learners in this study were in grade 9, content was left to the discretion of the teacher and the school. The 2005 grade 9 CTA for Natural Science did not test content needed for the 2006 grade 10 Physical Science. Learners could have had huge gaps of knowledge while passing the grade 9 examination. Curriculum 2005, therefore, did not adequately prepare learners for grade 10 Physical Science.

Classroom Observation

The teacher seemed to be unaware of new curriculum developments. There was little or no evidence of goal-setting to achieve curriculum outcomes. He focused on lesson objectives only and used a teacher-centred approach even in cases that lent themselves to learner-centred activities. His limited knowledge had serious implications for the extent to which the learners were exposed to the processes of investigation pursued by South Africa's learner-centred education policies. The teacher demonstrated no skill of making learning enjoyable and thus contributed to the decline in interest by the learners.

.

Interviews (8 learners)

In general, one can say that positive attitudes towards science decline during transition from GET (Natural Science) to FET (Physical Science). Six of the eight interviewees, all of them empiricist, indicated a decrease in interest in Physical Science and chose careers that did not involve Physical Science. Only three learners, all high achieving boys, two of them post-positivists, indicated an increase in interest in Physical Science.

Some learners lamented the loss of a closer relationship with their Natural Science teachers in the GET phase and most of them expressed disappointment at the lack of opportunities to do experiments in the FET phase, particularly chemistry experiments in Physical Science. They ascribed their poor conceptual understanding to the lack of practical work.

The transition was difficult for the majority of learners – they resorted to rote learning and cramming. They demonstrated misconceptions and incomplete or no understanding of the mole concept and Avogadro's hypothesis. Using the cross-border metaphor, one can describe this transition as hazardous (Cobern & Aikenhead, 1998).

CHAPTER SIX: SYNTHESIS

6.1 INTRODUCTION

This is the concluding chapter of a four-year longitudinal study into learners' experiences of transition from the Natural Sciences in the GET phase to Physical Science in the FET phase at a time of curriculum change. The learners who participated in the study were a unique cohort. They were the first group who started schooling under C2005. Throughout the GET phase they had been following the outcomes-based C2005. They were also the last group of learners to complete their compulsory schooling under that curriculum in 2005 because the curriculum was revised and content was re-introduced in the NCS when they started grade 10 in the FET phase in 2006. They were also the first group to complete the NCS in grade 12. The progress and experiences of this group from the GET band to the FET band should therefore have generated much interest from both the political and educational perspectives.

In this chapter, conclusions were drawn from the results to answer the research questions. Difficulties experienced during transition were discussed in detail. Reflecting on the study, I made the case that the gap encountered at the articulation of the transition perpetuated throughout the progression during the FET phase, ultimately leading to negative experiences and poor coping. Having highlighted the limitations and given directions for further study, I made recommendations for the appropriate sectors of education.

6.2 TRIANGULATION OF RESULTS

The study implemented a mixed methods approach, using various instruments. The previous two chapters provided a comprehensive analysis of the quantitative and qualitative data collected. A clear picture emerged by combining the results from the various sources. Triangulation of results, represented in Table 6.1 indicated that the different data sources yielded converging results. These results could therefore be regarded as trustworthy in the context of this case study.

Table 6.1 Triangulation of results

Research question	Results	Data source
(i) How can the transition from Natural Science in GET to Physical Science in the FET be characterized?	Less emphasis of experiments in FET	**Classroom observation**
	Content mismatch in science curriculum between GET and FET.	**Documentation**
	Huge difference in assessment practices.	
(ii) How do learners in the Gauteng province of South Africa experience the transition from Natural Science in the GET phase to Physical Science in the FET phase?	Interest in science increases at the interface between the GET and FET and then declines throughout the FET	**Interest questionnaire**
	Boys show a larger increase in interest in Physical Science than girls from grade 9 to grade 10	**Interview**
	Teacher-student relationship has drifted apart	
	Teacher-dominated lessons and teaching strategies do not meet expectations.	
	Lack of conceptual understanding,	**Diagnostic test**
	Boys do better on the NOS developmental subscale than girls and in the grade 11 exam	**Grade 11 exam**
	Physical Science learners scored significantly higher on the NOS subscale 'testable' than the non-Physical Science learners. They are also frustrated by lack of experiments	**NOS Questionnaire**
(iii) How can the learners' strategies and approaches for negotiating the transition be understood and explained?	Learners resort to cramming, reading (not doing) experiments, rote application of concepts and algorithms.	
	Career choice: mostly not in the Physical Sciences	
	Tendency towards post positivism provides better coping skills for examinations	

6.3 RESEARCH QUESTIONS REVISITED

6.3.1 Characterization of the transition

The first research question of the study was:

How can the transition from Natural Science in GET to Physical science in the FET be characterized?

Document analysis, classroom observations and interviews indicated that the transition was characterized by a discontinuity of the curriculum from outcomes based to content based teaching, inadequate pre-requisite knowledge for FET Physical Science, dissimilar assessment practices, different teaching strategies and less emphasis on practical work in the FET phase.

Analysis of documents confirmed that the discontinuity of the curriculum created a gap at the interface between the GET and FET bands. Learners in this study followed Curriculum 2005 when they were in grade 9, the curriculum in which content was left to the discretion of the teacher and the school. Those who graduated to grade 10 in 2006 were faced with a curriculum in which the assessment standards specified content to be taught. The grade 10 Physical Science teacher was faced with the daunting task of determining which aspects had been covered by the learners in grade 9 Natural Science and which had not been covered. As seen from document analysis, the aspects covered in grade 9 Natural Science Common Tasks for Assessment (CTA) were by no means testing knowledge required for grade 10 Physical Science. Further analysis of documentation showed that assessment methods for grade 9 and grade 10 differ markedly. In grade 9, 75% of the final mark was based on continuous assessment (CASS) and 25% on summative assessment. In grade 10 it is the other way round, with 25% of the final mark from CASS and 75% from the summative assessment at the end of the year. I contend that this contributed to the large repetition rate in grade 10.

Classroom observations were conducted in 2006 when the subjects were in grade 10. The teacher still used the old method of teacher-centred approach, even in cases which lent themselves to learner-centred activities. Rogan (2004), in his study of the implementation of

Curriculum 2005, also reported that the largest percentage of instructional time was spent on lecturing in most science classrooms. What concerns me more is his finding that in the practical domain there was 'room for lots of improvement' (p.174). In my study, in lessons 7 and 8, the teacher could have easily allowed the learners to practically observe the characteristics of metals with a simple, easily obtainable example of copper wire, bulb and a battery: solid, shining, malleable, conductor of heat and conductor of electricity. However, the teacher confined himself to short-term objectives of the lesson, largely ignoring assessment standards. His teaching method did not lend itself to imparting skills, such as critical thinking and problem-solving, drawing conclusions, identifying and controlling variables, evaluating conclusions, hypothesizing, measuring, predicting, observing and comparing. Furthermore, interviews revealed that learners were not exposed to practical work in the FET phase, as confirmed by classroom observation, with the teacher turning a practical lesson into a theoretical lesson. The gap between the teaching strategies in the GET and FET therefore extended throughout the progression through the FET due to teacher centred lessons and lack of practical work throughout the FET phase.

6.3.2 Learners' experiences of the transition

The second research question was:

How did learners in the Gauteng province of South Africa experience the transition from Natural Science in the GET phase to Physical Science in the FET phase?

The interest questionnaire, grade 11 examination scores, diagnostic test and interviews revealed declining interest in Physical Science, disappointment in relationships with teachers and teaching strategies, poor conceptual understanding and poor performance throughout the progression of the FET phase.

Generally, interest in science increased at the interface between the GET and FET and then it declined throughout the FET band. The initial increase in interest was shown to be significant for boys. Learners experienced the teacher-student relationship as distant in the FET band compared to the close relationship in the GET band. From interviews and classroom observation it was concluded that lack of experiments in FET did not meet their expectations regarding teaching strategies. Poor conceptual understanding was revealed by the diagnostic test, interviews and the poor average results in the grade 11 examination. I therefore argue that learners faced with these challenges would find it difficult to make a smooth transition from Natural Science to Physical Science. The majority of learners expressed the view that the transition was not smooth, rather that it was difficult. Using the cross-border metaphor, one can describe this transition as hazardous (Cobern & Aikenhead, 1998).

Interest in Science

In grade 9, boys and girls showed similar interest in Physical Science. In grade 10, learners' interest in science was found to increase at the articulation of the two phases (end of the GET phase to beginning of the FET phase). This emerged from the statistical analysis of the descriptive data from the interest questionnaire (IQNSFS) that was conducted towards the end of 2005 and again in the first half of 2006. The change in interest as learners moved from grade 9 to grade 10 was significant in the case of boys but not for girls. The increased interest in Physical Science amongst boys may be related to their tendency towards post-positivism. This tendency towards post-positivism was revealed by boys' significantly better performance on the developmental scale of the NOS questionnaire, discussed in the next section.

Positive attitudes towards science declined for most learners during the progression through the FET phase. For example, Hazel Planck remarked:

> *My interest in science is declining because in the FET phase it's more complicated. I think the work is more and you have to memorise all these terms.*

Three boys were the only ones to indicate increased interest during the progression. For example, Humphrey Edwards said:

> *I think it is increasing because from grade 10 to grade 12 we were introduced into new things like for instance momentum and the rates of reactions … you get to know how something happened that I did not understand how they occurred … but now through science I understand why is it that all things go down and not up … so I think being introduced to new things … things that are related to everyday life … I think it is increasing.*

The interviews were conducted when the learners were in their final year of the FET phase and were asked to reflect on the whole period from the GET to the FET. The result is in agreement with various studies in Australia that concluded that students' interest in and enjoyment of science decline sharply during the secondary school years (Baird, 1994). It appears that learners prefer the subjects in which they do well and will lose interest in those in which they perform poorly, as is the case with Physical Science in the FET phase. In the current study, learners indeed performed poorly as demonstrated by the grade 11 examination results. Of course, a lack of interest would also contribute to poor performance. The relationship between interest and performance therefore worked both ways creating a downward spiral of poor performance and lack of interest.

Most of the learners did not indicate Physical Science as their favourite subject. Reflecting on the interest questionnaire I found that there was no correlation between interest and achievement. It is therefore not surprising that high achievers in Physical Science had other subjects as their favourites. For example, the favourite subject for Hazel Planck was Mathematics:

> *My favourite subject is Mathematics because in Mathematics we do more with figures … and you have to calculate … it's not all about cramming the notes you are given … you have to know your subject and you have to practice.*

Learners' decreasing interest in Physical Science was related to the lack of practical work in the FET phase, as discussed below.

Disappointment with teaching strategies

The interviews showed that the teaching strategies in Physical Science did not meet the learners' expectations. It is my view that this disappointment contributed to the decrease of interest throughout the progression of the FET band. On the question of their expectations of teaching strategies in the FET band, the majority of learners expressed disappointment at the lack of opportunities to do experiments in the FET phase, particularly chemistry experiments in Physical Science. When asked if the teaching strategies in Physical Science met their expectations, typical responses were:

Hazel Planck: *No, it is not, because when I was in grade 8 and 9 we did a lot of experiments … science was more of a practical subject but as we get to grade 10 we get stories like a … things that we have to do like experiments … they are expensive and we can no longer do them …so science is now more like …you have to cram and … know terms by heart without actually seeing the things you are talking about.*

Henry Els: *When you have to do certain parts, especially in chemistry … that's where you have to do experiments .. so you find out that the school does not have enough material to help us out .. so you end up doing the experiment as part of theory.*

Howard Prins: ……. *most of the time we only do theory and we don't normally use the labs, especially in chemistry for practical so you can understand more if you do practical but when you only do theory sometimes it's hard to understand.*

The quotes above both confirmed that the learners found it hard to understand the FET science and that they ascribed their poor understanding to the lack of practical work. This is not surprising against the background of the mismatch of the GET and FET curricula. GET science is typically hands-on and is aimed at giving practice in problem-solving skills (Rennie, 1984; DoE, 2002(b)) and learners graduating from GET phase to FET phase were justifiably expecting the continuation of these hands-on activities. The learners expressed their disappointment at the lack of activities as well as listening to lectures, similar to results found by Baird (1994).

Learners' frustration over not having the opportunity to do experiments could be related to their understanding of the Nature of Science. There was a tendency to differ between the Physical Science group and the Commercial Science group with regard to the whole NSKS score and the difference between the groups was significant on the subscale 'testable' where the Physical Science group scored much higher. This could explain why the science learners were frustrated by the lack of experiments, because they generally believed that the validity of scientific knowledge was established through repeated testing against accepted observations. I propose that the exposure of Physical Science learners to Learning Outcome 1 on Scientific Investigations (DoE, 2002(b)) contributed to their understanding of the testable aspect of the Nature of Science, leading to their expectations to do experiments, and their disappointment at the lack of opportunity to actually do experimental work.

Disappointment with student-teacher relationships

On the question of teacher-student relationships, the majority of learners lamented the loss of a closer relationship with their Natural Science teachers in the GET phase as exemplified in the following responses:

> Humphrey Edwards: *I think from grade 10 downwards, the relationship was kind of a parent and child ... because we were not ... they still took us as children .. . like they had to guide us … talk to us … understand us but since from grade 10 to grade 12 sometimes we were taught by an HOD … he's got a lot of duties so actually he just comes to teach you … you only have time to talk in class because they teach different classes and some are deputy principals they have to do some things … so it's kind of a distant relationship*

> Henry Els: *It's different … because …from the early grades .. teachers try to make us have more love for science rather than the ones we have right now. In the FET section, they come to class, teach you and the other work is for you to do*

The disappointment was understandable, considering the fact that these learners experienced the caring culture of GET schooling and now found themselves in a more academically fragmented and competitive climate of FET schooling (Eyers, 1992).

Conceptual understanding and performance

The poor examination results in grade 11 as well as the poor performance in the diagnostic test revealed poor conceptual understanding. During interviews, the learners reported that they did not understand many of the new concepts. They blamed their lack of understanding solely on the lack of experimental work in class. They resorted to reading the experiments from the textbook, memorizing terms and rote application of concepts and algorithms when solving problems. Even the best performing student in science admitted to poor understanding, which she related to a lack of practical work:

> Hazel Planck: *My interest in science is declining because in the FET phase it's more complicated. I think the work is more and you have to memorise all these terms. It's more work and the chemistry part … I like the chemistry part as I was doing grade 9*

and grade 8 but as I got to grade 10 it was more difficult because there was a bit of change in the way it was taught and the way I understood it; and the other thing is that we don't have laboratory so we have to read the experiment from the text-book and cram it.

The poor performance and low confidence revealed by the diagnostic tests suggested poor conceptual understanding. The responses to the interviews following up on the diagnostic test confirmed that learners had a very poor understanding of a basic chemistry concepts like the mole and that they held misconceptions about Avogadro's law. When asked why he said all containers had one mole of each substance, Herman Pattington replied as follows:

I said all containers contain one mole … because when you use the formula $n = V/V_m$*, I get one mole for all the containers … since the volume of the containers is the same and the constant molar volume is the same, so I arrived at the same conclusion for all the containers.*

This is consistent with the misconception that Avogadro's hypothesis applies to all phases of matter. In general, I found learners' problem-solving strategies during transition to be rote application of concepts and algorithms and guesswork, a serious indictment on both the teaching strategy of the teacher and the learning style of the learners.

Misconceptions and lack of understanding can be related to various factors, including inadequate pre-requisite knowledge and the rote application of concepts and algorithms (Garnett & Treagust, 1990). In the current study the role of inadequate pre-requisite knowledge was a factor contributing to learners' difficulties in conceptual understanding, with this leading to rote learning and algorithmic problem solving as a coping mechanism.

6.3.3 Learners' strategies and approaches to negotiating the transition

The third research question was:

How can the learners' strategies and approaches for negotiating the transition be understood and explained?

The diagnostic test and interviews revealed that in general, learners resorted to cramming, rote application of algorithms and to avoiding career choices involving Physical Science. Also, the interest questionnaire and examination scores indicated that boys generally coped better than girls in negotiating the transition. The NOS survey indicated that boys were inclined towards post-positivism as they scored significantly better on the developmental subscale. This could explain boys' better coping, as measured by better performance in the examinations.

Rote learning and algorithmic problem solving

The diagnostic test assessed understanding of one of the basic concepts of chemistry, namely the mole. The test was also designed to reveal learners' problem solving strategies when faced with assessment that emphasized conceptual understanding. The test revealed algorithmic problem solving and rote learning. During interviews learners admitted that they used rote learning ('cramming').

The term rote learning has often been used to describe the study methods of learners. Learners are seen to memorize large portions of the textbook and then to reproduce this information in a test. Very often these learners have little real understanding of the study material. They look for key words in the question and then dump all the information that they think is relevant to the question. They rarely relate the information to the particular demands of the question (Van der Vyver, 2000). This was indeed the case with subjects in the current study.

Epistemological belief seemed to have an influence on coping with the transition because boys, who had a tendency towards post-positivism, outperformed girls in the examination. Although the boys scored an average of only 41%, it was significantly better than the girl's average score of 34%. I regard their better examination performance as evidence of better coping, and ascribe this to a tendency amongst boys towards post-positivism, as revealed by the NOS questionnaire, where the boys scored significantly higher than the girls with regard to the developmental subscale. I therefore argue that in general, the boys had a *tendency* towards post-positivism regarding their understanding of the developmental nature of science. I thus propose that the boys' tendency towards post-positivism can explain their better examination performance. This conclusion is in line with results of Lin and Chiu

(2004), who found that post-positivists outperform empiricists in conceptual problem solving. Post-positivists have a broader view of how science principles are related and this enhances problem solving.

However, the classification of individual learners as post-positivist and empiricist did not give a clear indication of better problem solving skills amongst post-positivists. Also, the mere fact that high achieving post-positivists, low achieving post-positivists, high achieving empiricists and low achieving empiricists co-existed, supported the absence of a statistical significant correlation between the overall NOS score and achievement in the examination. The classification may be an oversimplification under conditions of general poor understanding and poor performance as those exposed by the diagnostic test and interviews.

Career choices

Most learners chose to focus on careers outside the Physical Sciences. I propose that learners' negative attitudes lead to avoidance of careers in the Physical Sciences. The ultimate coping strategy seemed to be that learners chose careers that do not involve the Physical Sciences as a way of trying to cope with or avoid transitional problems relating to Physical Science. Ironically, the best achiever in Physical Science was not attracted to a career in the Physical Sciences. In the interviews, the two learners who did choose careers in science were both high performing boys. This supported the assertion that boys were coping better.

6.3.4 Conclusion

Learners in this study who were doing grade 9 Natural Science in 2005 were greatly disadvantaged by the curriculum that did not prepare them adequately for grade 10 Physical Science. The transition from Natural Science in GET to Physical Science in FET was described in terms of the gap model proposed by Rollnick et al. (1998). The discontinuity at the interface between grade 9 and grade 10 was described as the articulation aspect of the gap while the progression aspect of the gap described the mismatch between the output of the GET phase and the requirements throughout the FET phase. The mismatch of content, assessment and teaching strategies which characterized the transition ruled out the possibility of a smooth transition; the characteristics of the transition resulted in negative experiences and poor coping.

Document analysis confirmed the gap between C2005 and the NCS regarding science content knowledge as well as assessment strategies. The lack of prescribed content in the GET phase led to poor understanding at the articulation. Inevitably, the poor understanding at the articulation of the gap snowballed throughout the progression as learners had no base onto which they could construct new knowledge. The continued poor understanding was reflected by poor grade 11 examination scores and poor performance in the diagnostic test taken in grade 12.

Regarding assessment, the discontinuity was not limited to the articulation of the gap, but persisted throughout the progression. The significant difference in the way continuous assessment contributed towards the final mark in grade 9 and grade 10 (75% and 25% respectively) probably contributed towards the huge retention rate in grade 10. Furthermore, it is well known that parents contribute greatly towards their children's achievement in continuous assessment (which includes homework, assignments and projects) and therefore it was relatively easier for learners to pass grade 9 than to pass grade 10. Furthermore, the emphasis on formative assessment in the GET phase did not support the development of study skills required for the summative assessment in the FET phase, as confirmed by learners' admitting that they studied by 'cramming'. The high retention rate in grade 10 could therefore be attributed, amongst other factors, to the assessment gap, as well as the knowledge gap at the interface of the GET and FET.

There was a significantly better examination achievement amongst boys. The boys also scored significantly higher on the developmental scale of the NOS questionnaire. I therefore argue that the boys' tendency to be post-positivist resulted in better problem solving skills, which led to their better achievement in the examinations and better coping with the transition.

Initially, there was an increase in interest shown in science from grade 9 to grade 10, but this interest declined as learners progressed to grade 12. I propose that the decline in interest in Physical Science was caused by a lack of practical work, poor understanding, poor performance, teacher centred lessons, and a loss of close student-teacher relationships. The learners themselves described the transition as difficult.

From interviews, it was clear that the learners *believed* that their poor understanding was caused by not doing experiments in class. The learners' firm belief in the value of experiments was supported by their high scores on the 'testable' scale of the NOS questionnaire. Furthermore, the learners' wish for experimental work agrees with Gabel (1999) who argues that concepts in science, chemistry in particular, are abstract and difficult to explain without the use of analogies or models. However, I believe that experimental work would not solve all problems. Though essential, experiments should not be seen as an alternative for basic content knowledge and conceptual understanding. After all, science is a difficult subject, even for privileged learners who do all the experiments in class.

In the diagnostic test, when faced with problems of conceptual understanding, most learners resorted to guess work and rote application of concepts and algorithms. Once again, the reason was probably complicated. Firstly, the lack of foundational knowledge inherited from C2005 can be regarded as a fundamental factor. Of course, this could be compounded by unproductive teaching strategies as was confirmed by lesson observations and interviews with learners. The poor quality of teaching in the FET is a problem in its own right, but it certainly compounded transitional problems.

Also, teachers' limited knowledge placed serious restrictions on the extent to which the learners were exposed to the processes of investigation pursued by South Africa's learner-centred education policies. The government had long conceded that Black science teachers' subject knowledge and professional confidence were generally poor, as "a cycle of mediocrity perpetuates itself through their efforts in the classroom" (Government Gazette, 1995, p31). It was further pointed out in the *Government Gazette* that if this cycle were wasteful from an educational point of view, it was catastrophic from the perspective of national developmental needs. There is a need for 'a significant empirical agenda' (Apple, 1986) on science teachers. This agenda includes Rogan's (2004) appeal for greater initial text 'structure' for teachers. Ultimately, what is needed is a comprehensive and far-reaching teacher development initiative (Stoffels, 2004).

The class of 2008 obtained disappointing results in the final grade 12 Physical Science examinations. Both provincial and national results of the class of 2008 are given in Appendix M. In Gauteng only about 37% of candidates obtained 40% and above, while nationally the figure is even lower at about 29%. Appendix N gives the pass requirements for the National

Senior Certificate (NSC). The results for Physical Science are disappointing considering that it would require at least three subjects at 40% or above for one to obtain the NSC. Finally, the poor performance in the final Physical Science examination ultimately confirmed the difficult transition to the FET phase and poor coping throughout the FET phase for the class of 2008.

6.4 LIMITATIONS TO THE STUDY

Amongst the limitations of the study were that it was a case study of one school. Furthermore, the school was within a previously disadvantaged community. The effects of the teachers' and students' backgrounds on scientific understanding were not explored. Transitions could very well have been smooth in privileged communities where schools were well resourced and teachers well trained. Also, in the diagnostic test, learners were not given the actual samples of the chemicals, which might have influenced the responses and I acknowledge these as weaknesses in the study. As the findings are based on the Natural Science learning area and the Physical Science subject some findings are likely to be common with what would be found with other subjects, but some of them may be unique to Natural Science and Physical Science.

6.5 DIRECTIONS FOR FURTHER RESEARCH, IMPLICATIONS FOR SCIENCE EDUCATION AND RECOMMENDATIONS

There is a need for more longitudinal studies of this nature to understand learners' difficulties to cope with curricula, especially when new curricula are introduced.

The interface between the GET and FET appears to be the critical time when learners make decisions about subject and career choices, so it is important that the excitement about science with which they enter the FET phase (grade 10) should be built upon by offering exciting science programs that are suitable for adolescents.

It is of critical importance that curriculum developers should concern themselves with matching of curricula across phases. Assessment strategies across phases should also be aligned. Comprehensive planning is one of the key elements to successful transitions, as Patton and Dunn (1998) noted when they explained Halpern's model of transition. Such comprehensive planning should precede curriculum changes to minimize hazardous transitions. Well planned transitions would minimize discontinuity in the curriculum and create an atmosphere that is conducive to progress in the classroom.

The Department of Education could assist science teachers in making their teaching more relevant, meaningful and interesting. Teacher training courses should incorporate recent research findings in science education. In-service training should be held with the aim of improving teaching strategies and content knowledge. Promoting students' understanding of the NOS is might result in higher conceptual problem-solving ability (American Association for the Advancement of Science, 1989), which would facilitate a smooth transition in science. Diagnostic tests on basic concepts in Physical Science should be introduced in order to diagnose obstacles to the understanding of science concepts.

Grade 9 Natural Science and grade 10 Physical Science educators could form cluster committees with the aim of trying to close the gap at the interface of the two phases. To facilitate a smooth transition, the committees should ensure that GET and FET educators have comprehensive plans that include a thorough needs analysis of learners and the receiving setting.

Finally, all role players should work towards creating manageable transitions for science learners into the FET phase. Smooth transitions could encourage more learners to choose scientifically based careers. In the long run, well informed and well planned support to science teaching will bear fruits of improved performance in science, economic growth and a scientifically literate community.

REFERENCES

Abell, S.K. (2002). Placing the 'what if' before the 'why'. In: J. Wallace and W. Loden (Eds), *Dilemmas of Science Teaching: Perspectives on Problems of Practice* (pp. 153 – 155). London & New York: RoutledgeFalmer.

Airasian, P.W. & Gay, L.R. (2003). *Educational research: competencies for analysis and applications*.Upper Saddle River, N.J.: Merrill/Prentice Hall.

Aird, D. (1989). *The mole concept - A study of pupil difficulties*. Unpublished Honours Project. Johannesburg: University of the Witwatersrand.

Aiken, L.R. (1979). Attitudes toward mathematics and science in Iranian middle schools. *School Science and Mathematics,* 79, 229 - 234

Aikenhead, G.S. (1996). Science education: border crossings into the subculture of science. *Studies in Science Education*, 27, 1 – 52.

American Association for the Advancement of Science (1989). *Science for all Americans*. Washington DC: American Association for the Advancement of Science.

Anderson, K., Case, A. and Lam, D. (2001). Causes and Consequences of Schooling Outcomes in South Africa: Evidence from Survey Data. *Social Dynamics, Vol. 27*(1) 37 – 59.

Anderson, L.W., Jacobs, J., Schramm, S. & Splittgerber, F. (2000). School transitions: beginning of the end or a new beginning? *International Journal of Educational Research, 33*, 25 – 339.

Apple, M. (1986*). Teachers and texts: A political economy of class and general relationship*. New York: Routledge & Kegan Paul.

Arends, F. (2008). Understanding Teacher Demand in South Africa. Teacher Education Series. Cape Town: HSRC Press.

Arnott, A., Kubeka, Z., Rice, M. and Hall, G. (1997) *Mathematics and science teachers: Demand, utilization, supply and training in South Africa.* Johannesburg, South Africa. Edusource.

Atwood, R.K. & Atwood, V.A. (1996). Preservice primary teachers' conceptions of the causes of seasons. *Journal of Research in Science Teaching, 33*(5), 553 – 563.

Australian Science, Technology and Engineering Council (ASTEC) (1997). *Foundations for Australia's Future: Science and Technology in Primary Schools*. Canberra: Australian Government Publishing Service.

Ayers, J.B. and Price, C.O. (1975). Children's attitudes toward science. *School Science and Mathematics*, 75, 311 – 318.

Baird, J.R. (1994). A framework for improving educational practice: Individual challenge. In: J. Edwards (Ed.), *Thinking: International interdisciplinary perspectives.* Victoria: Hawker Brownlow Education.

Baird, J.R. & Penna, C. (1992). Survey Research. In: J.R. Baird (Ed.), *Shared adventure: A view of quality teaching and learning* (Second Report of the Teaching and Learning Science in School Project) (pp. 185 – 274). Victoria: Monash University.

Baird, J.R., Gunstone, R.F., Penna, C.,Fensham, P.J. and White, R.T. (1990). Researching balance between cognition and affect in science teaching and learning. *Research in Science Education*, *20*, 11 – 20.

Baurnert, J. (1995). *Gender, science interest, teaching strategies and socially shared beliefs about gender roles in seventh graders – A multi-level analysis*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Francisco.

Behr, A.L. 1983. *Empirical research methods for the human sciences*. Durban: Butterworths.

Black, P., Harrison, C., Osborne, J. & Duschl, R. (2004). *Assessment of Science Learning 14 -19.* A report prepared for the Royal Society. King's College, London. University of London.

Blyth, D.A., Simmons, R.G. & Bush, D.M. (1978). The transition into early adolescence: A longitudinal comparison of youth in two educational contexts. *Sociology of Education, 51,* 149 – 162.

Bohardt, P.C. (1975). Attitudes toward process-based science instruction held by students and teachers in grades four through eight. *Dissertation Abstracts International,* 35,5981A.

Bradely, J.D., Brand, M. & Langley, F. (1985). Towards an understanding of the school-university gap in chemistry. *South African Journal for Higher Education 5*(2): 70 –73.

Braund, M. (2002). STAYing the course: smoothing the transfer from Key Stage 2 to Key Stage 3. *Education in Science, 197,* 28–29.

Braund, M., Crompton, Z., & Driver, M. (2003). *'STAY' project research briefing No.2. First report on the evaluation of bridging work in science in York schools.* York: Department of Educational Studies, University of York.

Braund, M. and Hames, V. (2005) Improving progression and continuity from primary to secondary science: pupils' reactions to bridging work, *International Journal of Science Education,* 27 (7), 781-801.

Brickhouse, N. (1990). Teachers' beliefs about the nature of science and their relation to classroom practice. *Journal of Teacher Education, 41,* 53 – 62.

Brown, G. L., Amwake, C., Speth, T. and Scott-Little, C. (2002). The continuity framework: a tool for building home, school and community partnerships. *Early Childhood Research and Practice. Vol. 4* (2).

Bunyan, P. (1998). Comparing pupil performance in Key Stages 2 and 3 science SATs, *School Science Review, 79*(289), 85–87.

Cantrell, M.A., Kouwenhoven, W., Mokoena, T. & Thijs, G. (Eds) (1993). *Bridging school and university. The Pre-University course at the University of Botswana*. Amsterdam: VU Press.

Carnoy, M. & Chisholm, L. (2008). *Towards Understanding Student Academic Performance in South Africa: A Pilot Study of Grade 6 Mathematics Lessons in South Africa.* Report prepared for the Spencer Foundation. Pretoria: HSRC.

Carramaza, A., McCloskey, M. & Green, B. (1981). Naive beliefs in "sophisticated" subjects. *Cognition*, 9, 117 – 123

Carreira, T. and Andre, J. (2000). Transition from "compulsory"education to "voluntary" education: Some causes of the crisis. *Educacao Individuo Sociedade, 1* (1), 123 – 142.

Chadbourne, R. (1995). Curriculum makers or curriculum takers? The influence of tertiary selection on secondary schools. *Issues in Educational Research*, *5*(1), 1 – 9.

Cho, H., Kahle, J.B. & Nordland, F.H. (1985). An investigation of high school textbooks as sources of misconceptions and difficulties in genetics and some suggestions for teaching genetics. *Science Education*, *69*(5), 707 - 719.

Chisholm, L. (2000). *A South African curriculum for the 21st century. Report of the Review Committee on Curriculum 2005.* Pretoria.

Choppin, B. and Frankel, R. (1976). The three most interesting things. *Studies in Educational Evaluation*, 2, 57 – 61.

Christie, P. (1993). Equality and curriculum policy in post-apartheid South Africa. *Journal of Education, 18*(1) 5 – 17.

Cobern, W.W. and Aikenhead, G.S. (1998). Cultural aspects of learning science. In: B.J. Fraser and K.G. Tobin (Eds.), *International Handbook of Science Education* (pp. 39 – 52). Dortrecht, The Netherlands: Kluwer Academic Publishers.

Cohen, L. and Manion, L. (1994). *Research Methods in Education*. London, Routledge.

Collette, A.T. and Chiappetta, E.L. 1984. *Science instruction in the middle and secondary schools.* Toronto: Times Mirror/Mosby college publishing.

Confrey, J. (1990*).* A review of research on student conceptions in Mathematics, Science and Programming, In: Cazden, C. (Ed). *Review of Research in Education* (pp. 3 – 56).

Creswell, J.W. (2003). *Research Design. Qualitative, Quantitative and Mixed Methods Approaches* (2nd Ed.). London. Sage Publications.

Crockett, L.J., Peterson, A.C., Graber, J.A., Schuleners, J.E. & Ebata, A. (1989). School transitions and adjustments during early adolescence. *Journal of Early Adolescence*, *9*,181 – 210.

Crowther, J., Kavanagh, K. and Ashby, M.(Eds). (1995). *Oxford advanced learners' dictionary of current English*. Oxford. Oxford University press.

Davies, D. & McMahon, K. (2004). A smooth trajectory: developing continuity and progression between primary and secondary science education through a jointly-planned projectiles project. *International Journal of Science Education, 26* (8), 1009 – 1021.

Dawson, R. and Shipstone, D.M. (1991). Liason in science at the primary-secondary interface. *School Science Review, 72*(261), 19 – 25.

Dekkers, P. & Mnisi, E. (2003).The Nature of Science – Do teachers have the understandings they are expected to teach?. *African Journal of Research in SMT Education, 7,* 21 – 34.

Demetriou, H., Goalen, P. & Rudduck, J. (2000). Academic performance, transfer, transition and friendship: listening to the student voice. *International Journal of Educational Research, 33,* 425 – 441

Denzin, N.K. and Lincoln, Y.S. (Ed). (1994). *Handbook of Qualitative Research.* London, Sage Publications.

Department of Education(DoE), Government of South Africa. (1997). *Senior Phase (Grades 7 to 9). Policy Document*. Pretoria. Government Printers.

Department of Education(DoE), Government of South Africa. (2002(a)). *Educator Guide To Phase OBE into FET 2002 – 2005*. Pretoria. Government Printers.

Department of Education(DoE), Government of South Africa (2002(b)*). Revised National Curriculum Statement Grades R – 9. (Schools) Policy – Natural Sciences*. Government Gazette, *443* (23406). Pretoria. Government Printers.

Department of Education (DoE), Government of South Africa (2005(a)). *Teachers for the future: meeting teacher shortages to achieve education for all.* Pretoria. Government Printers.

Department of Education(DoE), Government of South Africa (2005(b)). *Natural Scien*ce (NS). *Common Tasks for Assessment (CTA).Grade 9*. Pretoria. Government Printers.

Department of Education(DoE), Government of South Africa (2005(c)).*National Curriculum Statement, Grades 10 – 12 (General). Subject Assessment Guidelines. Physical Scien*ces. Pretoria. Government Printers.

Department of Education(DoE), Government of South Africa (2006(a)*). National Curriculum Statement Grades R – 9. Orientation Programme Grades 8 & 9. Participant's Manual – Generic.* Pretoria. Government Printers.

Department of Education(DoE), Government of South Africa (2006(b)*). National Curriculum Statement. National Policy on Assessment and Qualifications for schools in the General Education and Training band.* Pretoria. Government Printers.

Department of Education(DoE), Government of South Africa (2007). *National Senior Certificate. Grade 11. Physical Sciences/P2 (Chemistry).* Pretoria. Government Printers. Retrieved March 31, 2008 from http://www.education.gov.za/Curriculum/GR%2011%20QP%20NOVEMBER%202007%20submission/Physical%20Science/P2/Physical%20Sc%20P2%20_Chemistry_%20Gr%2011%20-%20Nov%202007.pdf

Department of Education(DoE), Government of South Africa (2009). *Technical Report: National Senior Certificate Results 2008*. Pretoria. Government Printers.

Department of Education and Science/Welsh Office. (1985). *Science 5–16: A statement of policy.*London: Department of Education and Science and the Welsh Office: HMSO.

Department of National Education, (DNE), Government of South Africa (1989). A Resume of Instructional Programmes in Public ordinary schools. NATED 02 – 550 (89/03). Pretoria: DNE.

Doyle, L., & Hetherington, N. (1998). Learning progression across the primary/secondary divide. All-in Success. *Journal of the Centre for The Study of Comprehensive Schools (CSCS), 9*(2), 9–12.

Driver, R. & Easley, J. (1978). Pupils and paradigms: A review of literature related to concept development in adolescent science students. *Studies in Science Education*, *5*, 61 – 64.

du Toit, S.J. (1992*). Special Empirical Education (BEd)*. Pretoria: Unisa.

Duschl, R. (1990). Restructuring science education. New York: Teachers College Press.

Education Labour Relations Council (ELRC, 2003). *Collective Agreement Number 8 of 2003. Integrated Quality Management System*. Pretoria.

Education policies. Available at www.education.gpg.gov.za. Accessed 30 June 2006.

Ely, M., Anzul, M., Friedman, T., Garner, D. & Steinmetz, A.C. (1991*). Doing qualitative research: Circles within circles.* New York: Falmer.

Entwistle, N. (1981). *Styles of learning and teaching.* New York. Brisbane. Toronto: John Wiley and Sons.

Erasmus, J. and Mda, T. (2008) '*Scarce and Critical Skills: Educators'*. Unpublished Report prepared for the Department of Labour project on Scarce and Critical Skills. Pretoria: HSRC.

Erickson, F. (1990). *Qualitative methods: research on teaching and learning, vol 2.* New York. Macmillan.

Erlandson, D.A., Harris, E.L., Skipper, B.L. & Allen, S.D. (1993). *Doing naturalistic enquiry: A guide to methods.* Newbury Park, CA: Sage.

Eyers, V. (1992). *The Education of young adolescents in South Australian government schools.* Report of the junior secondary review. Adelaide: Education Department of Australia.

Fensham, P.J. (1999). *Science content as problematic: issues of research.* Rosalind Driver Memorial Lecture, ESERA, Kiel, Germany.

Fensham, P., Navaratnam, K., Jones, W. & West, L. (1991). Students' estimates of knowledge gained as measures of the quality of teacher education. *Research in Science Education, 21,* 80 – 89.

Finn, J.D. (1989). Withdrawing from school. *Review of Educational Research*, 59, 117 – 142.

Fisher, K.M. (1983). Amino acids translation: A misconception in biology. In: H. Helm & J.D. Novak (Eds). *Proceedings of the International Seminar: Misconceptions in Science and Mathematics*. Ithaca, New York: Cornell University Press.

Fonseca, J.M.B. and Conboy, J.E. (2006). Secondary student perceptions of factors effecting failure rate in science in Portugal. *Eurasia Journal of Mathematics, Science and Technology Education*. *2*(2). 81 – 95.

Gabel, D.(1999). Improving Teaching and Learning through Chemistry Education Research: A Look to the Future. *Journal of Chemical Education*, *76*(4), 548.

Gallagher, J.J. (1991). Prospective and practising secondary school science teachers' knowledge and beliefs about the philosophy of science. *Science Education*, *75,* 121 – 134.

Galton, M. (2002). Continuity and progression in science teaching at Key Stages 2 and 3. *Cambridge Journal of Education, 32*(2), 250–265.

Galton, M., Gray, J., & Ruddock, J. (1999). *The impact of school transitions and transfers on pupil progress and attainment. Research report RR 131.* London: Department for Education and Employment.

Galton, M. & Morrison, I. (2000). Concluding comments. Transfer and transition: the next steps. *International Journal of Educational Research*, 33(4), 443 – 449.

Garnett, P.J. & Treagust, D.F. (1990). Implications of research on students' understanding of electrochemistry for improving science curricula and classroom practice. *International Journal of Science Education* , 12: 147 - 156.

Gauteng Department of Education (GDE, 2005). *Annual Report 2004/2005 - Including Audited Financial Statements.* Pretoria. Government Printers.

Gauteng Department of Education (GDE, 2006). *Orientation Programme. Physical Science Grade 11 & 12. National Curriculum Statement (NCS). Participant's Manual. Physical Science: NCS Training*. Pretoria. Government Printers.

Gauteng Department of Education (GDE, 2008). *Annual Performance Plan, 2007/08 to 2009/10.* Pretoria. Government Printers.

Gay, J. and Airasian, P. (2003). *Educational research: competencies for analysis and applications.* New Jersey. Merrill/Prentice Hall.

Gerard, S & See B.H. (2009). The impact of socio-economic status on participation and attainment in science. *Studies in Science Education*, 45, 93-129.

Giroux, H. (1992). *Border Crossings: Cultural Workers and the Politics of Education.* New York: Longman.

Glesne, C. & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction*. White Plains, NY: Longman.

Goodrum, D., Cousins, J. & Kinnear, A. (1992). The reluctant primary school teacher. *Research in Science Education, 22,* 163 – 169.

Government Gazette (15 March 1995). *White paper on Education and Training, 16312,* 30 – 31.

Grayson, D.J. (1996). A holistic approach to preparing disadvantaged students to succeed in tertiary science studies Part 1. Design of the Science Foundation Programme (SFP). *International Journal of Science Education*, *18*(8), 993 – 1013.

Halpern, A.S. (1994). The transition of youth with disabilities to adult life: A position statement of the Division on Career Development and Transition, *The Council for Exceptional Children. Career Development for Exceptional Individuals, 17,* 115 – 124.

Hargreaves, A. & Earl, L. (1994). Triple transitions: Educating early adolescents in the changing Canadian context. *Curriculum Perspectives, 14*(3), 1 – 9.

Hargreaves, L. & Galton, M. (2002). *Transfer from the primary classroom: 20 years on.* London: RoutledgeFalmer.

Hartshorne, K. (1992) *Crisis and challenge: Black education 1910-1990.* Cape Town, South Africa: Oxford University Press.

Hewson, M. (1988). Perspectives of research on learning difficulties and methods of identifying students' conceptions. In: Thijs, G.D. et al (Eds) *Learning Difficulties and Teaching Strategies in Secondary School Science and Mathematics* (pp. 27 – 41). Amsterdam: Free University Press.

Hobbs, E.D. and Erickson, G.L. (1980). Results of the 1978 British Columbia Science assessment. *Canadian Journal of Education*, *5*, 63 – 80.

House of Commons Education Committee (1995). *Fourth report: Science and technology in schools.* London: HMSO.

Jacobs, L.J. and Vrey, J.D. (1982). *Selfkonsep, diagnose en terapie: 'n opvoedkundig-sielkundige benadering*. Pretoria: Academica.

Jansen, J.D. (1997). Why education policies fail. *Indicator SA, 12*(2) 56 – 58.

Jansen, J.D. (1999). Á very noisy OBE': The implementation of OBE in Grade 1 classrooms. In: Jansen, J & Christie, P. (Eds). *Changing curriculum: Studies on outcomes-based education in South Africa* (pp. 203 – 219). Cape Town: Juta.

Jewett, J., Tertell, Liz., King-Taylor, M. Parker, D., Tertell, Lin and Orr, M. (1998). Four early childhood teachers reflect on helping children with special needs make the transition to kindergarten. *The Elementary School Journal*, *98* (4), 329 – 338.

Johnson, R.T. (1981). Children's attitudes toward science. *Science and Children*, *18*, 39 – 41.

Kagan, S. L. and Neuman, M. J. (1998). Lessons from three decades of transition research. *The Elementary School Journal*, *98* (4), 365 – 379.

Kelly, V.L.(1995). An Exploration of Pre-service Teachers' Experiences of the Higher Diploma in Education and Aspects of their Subject Matter Knowledge. Unpublished M.Sc Research Report. University of the Witwatersrand.

Kempa, R.F. and Ward, J.E. (1988). Observational thresholds in school chemistry, *International Journal of Science Education*, *10* (3), 275-284.

Klee, R. (1997). Introduction to philosophy of science: Cutting nature at its seams. New York, USA: Oxford University Press.

Kurita, J.A. & Janzen, H.L. (1996). *The role of social support in mediating school transition stress.* Paper presented at the Annual Meeting of the American Psychological Association, Toronto.

Lederman, Abd-El-Khalick, Bell & Schwartz (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, *39,* 497 – 521.

Lederman, N.G. and Zeidler, D.L. (1987). Science teachers' conceptions of the nature of science: do they really influence teacher behavior? *Science Education, 71,* 721 – 734.

Lin, H.S & Chiu, H.L. (2004). Student understanding of the nature of science and their problem-solving strategies. *International Journal of Science Education, 26*(1), 101–12.

Lincoln, Y.S. and Guba, E.G. (1985). *Naturalistic Inquiry.* London: Sage Publications.

Linn, M.C. and Hyde, J. (1989). Gender, mathematics and science. *Educational Researcher*, *18*(8), 17 – 27.

Linneman, S.R., Lynch, P., Kurup, R., Webb, P. and Bantwini, B. (2003). South African science teachers' perceptions of the nature of science. *African Journal of Research in Science, Mathematics and Technology Education*, *7*, 35 – 50.

Mackay, M. (1973). *Onderhoudvoering: 'n basiese tegniek by voorligting en personeelkeuring*. Pretoria: Van Schaik.

Mail & Guardianonline (2008). Pandor: Significant school dropout rate after grade 9, 5 February, 2008.

Malcolm, C. (1999). Thoughts from South Africa: The Content of Science. *Science Teachers Association of Victoria, Australia, Labtalk, 43*(5), 28 – 29.

Malcolm, C. (2000). *Implementation of outcomes based approaches to education in Australia and South Africa: A comparative study*. Johannesburg: Radmaste Centre, University of the Witwatersrand,

Mangione, P. L. and Speth, T. (1998). The transition to elementary school: a framework for creating early childhood continuity through home, school and community partnerships. *The Elementary School Journal, 98* (4), 381 - 397.

Manyatsi, S (1996). The interface between junior and senior secondary school chemistry in Swaziland. Unpublished Ph.D thesis. Johannesburg: University of the Witwatersrand.

Maree, J.G. (2003). *Learning Guide: Introduction to Quantitative Research (NME 732). Faculty of Education.* Pretoria: University of Pretoria.

Marnewick, L. & Spreen, C. (1999). Dancing with the monster: Mastering the steps of OBE in the Northern Province. Unpublished Research Report. Johannesburg: University of the Witwatersrand.

McCloskey, M. (1983). Intuitive physics. *Scientific American 248*, 122 - 130.

McComas, W. & Olson, J.K. (1998). The nature of science in international science education standards documents. In McComas, W. (ed). The Nature of Science in science education (41 – 52). Dordrecht: Kluwer.

McMillan, J.H. & Schumacher, S. (2006). *Research in education: evidence-based inquiry* (6th ed). Pearson Education, Inc.

Merriam, S. (1988). *Case study research in education: A qualitative approach*. San Fransisco: Jossey-Bass.

Miles, M.B. & Huberman, A.M. (1994). *Qualitative data analysis: A sourcebook of new methods* (2nd ed.). Thousand Oaks, CA: Sage.

Mittlefehldt, B. (1985). Changing priorities in primary science. *Curriculum review*, *24*(4), 67 – 69.

Mizelle, N.B. (1995). *Transition from middle school to high school: The student perspective.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco.

Morris, C. (1995). *Lev Semyonovich Vygotsky: Psychology's first metacognitivist*. Unpublished manuscript of Education.

Mouton, J. (2001). *How to succeed in your Master's & Doctoral Studies – A South African Guide and Resource Book*. Pretoria: Van Schaik Publishers.

Mulder, J.C. (1986). *Statistical techniques in education*. Pretoria. Haum Tertiary Publishers.

Murphy. P. & Beggs, J. (2001). Students' attitudes, perceptions and understanding of primary science: comparisons between Northern Irish and English schools. Paper presented at the BERA conference, University of Leeds, UK.

Nekhwevha, F. (1999). No matter how long the night, the day is sure to come: culture and educational transformation in post-colonial Namibia and post-apartheid South Africa. *International Review of Education. 45*(5) 491 - 506

Nicholls, G., & Gardner, J. (1999). *Pupils in transition: Moving between Key Stages.* London: Routledge.

Norman, O & Elliot , T. (1993). *A content analysis of CEPUP – an STS middle schools curriculum,* Paper presented at the Annual Convention of the National Association for Research in Science Teaching, Atlanta.

Nott, M., & Wellington, J. (1999). The state we're in: Issues in Key Stage 3 and 4 science. *School Science Review, 81*(294), 13–18.

Novick, S. & Menis, (1976). A study of students' perceptions of the mole concept. *Journal of Chemical Education*, *53*(11),720 - 722.

Ntshingila-Khosa, R. (2001). *Teacher responses to curriculum reform: A comparative study of primary schools in South Africa*. Unpublished Ph.D Thesis, University of Cambridge, St. John's College.

Osborne, R.J., Bell, B.F. & Gilbert, Y.K. (1983). Science teaching and children's view of the world. *European Journal of Science Education*, *5*, 1 - 14.

Overton, M. and Reiss, M. (1990). A survey of teachers' views on the transition to A-level biology from GCSE. *Journal of Biological Education, 24*(2), 100 – 102.

Patton, J.R. & Dunn, C. (1998). *Transition from school to Young Adulthood. Basic Concepts and Recommended Practices.* Texas. Pro-ed. Inc.

Patton, M.Q. (1980). *Qualitative evaluation methods.* Beverly Hills, CA: Sage.

Patton, M.Q. (1990). *Qualitative evaluation methods and research methods.* Newbury Park, CA: Sage

Phillips, D.C. & Burbules, N.C. (2000). *Postpositivism and Educational Research*. Rowman & Littlefield Publishers.

Pietarinen, J. (2000). Transfer to and study at secondary school in Finnish school culture: developing schools on the basis of pupils' experiences. *International Journal of Educational Research, 33,* 383 – 400.

Pointon, P. (2000). Students' views of environments for learning from primary to secondary school, *International Journal of Educational Research, 33,* 375–382.

Pope, M. and Gilbert, J. (1983). Personal Knowledge and Construction of Knowledge in Science. *Science Education. 67*(2), 193 – 203.

Qualifications and Curriculum Authority. (2002). *Transition units (English and Mathematics).* London: Qualifications and Curriculum Authority.

Ramey, S. L. and Ramey, C. T. (1998). The Transition to School: Opportunities and Challenges for Children, Families, Educators, and Communities. *The Elementary School Journal, 98* (4), 293 – 295.

Reddy, V., Dlamini, N. and Ntshingila-Khosa, R. (2004). *Investigate the reasons for the low pass rate in grade 10 in 2003.* A report commissioned by the Department of Education Task Team. South African Department of Education.

Rennie, L.J. (1984). *Why teach science?* Proceedings of the Ninth Annual Conference of the Western Australian Science Education Association (pp. 47-52). Perth, Western Australia.

Rennie, L.J. (1990). Student participation and motivational orientations: what students do in Science, In: Tobin, K., Kahle, J.B. and Fraser, B.J.: *Windows into Science Classrooms: Problems Associated with Higher-Level Cognitive Learning.* London: The Falmer Press.

Rennie, L.J. & Parker, L.H. (1993). Curriculum reform and choice of science: Consequenses for balanced and equitable participation and achievement. *Journal of Research in Science Teaching, 30*(9), 1017 – 1028.

Rens, E.M.M. van, & Dekkers, P.J.J.M. (2001). Learning about investigations – the teachers's role. In: Behrendt, H., Dahncke, H., Duit, R., Graeber, W., Komorek, M.,Kross, A. & Reiska, P. (Eds*). Research Teachers' understanding of the NOS in Science Education – past, present and future* (pp. 325 – 330). Dordrecht: Kluwer Academic Publishers.

Rice, J.K. (1997). *Explaining the negative impact of the transition from middle to high school on student performance in mathematics and science: An examination of school discontinuity and student background variables.* Paper presented at the Annual Meeting of the American Educational Research Association, 1997, Chicago.

Roderick, M. (1993). *The path of dropping out*. Westport, CT: Auburn House.

Rogan, J.M. (2004). Out of the frying pan… ? Case studies of the implementation of Curriculum 2005 in some science classrooms. *African Journal of Research in Mathematics, Science and Technology Education. 8,* 165-179.

Rogan, J.M. & Gray, B.V. (1999). Science education as South Africa's Trojan horse. *Journal of Research in Science Teaching*, *36,* 373-385.

Rogan, J.M. and Grayson, D.J. (2003). Towards a theory of curriculum implementation with particular reference to science education in developing countries. *International Journal of Science Education, 25*(10), 1171 – 1204.

Rollnick, M., Manyatsi, S., Lubben, F & Bradely, J. (1998). A model for studying gaps in education: a Swaziland case study in the learning of science. *International Journal of Educational Development*. *18*(6) 453 – 465.

Rosier, M.J. and Banks, D.K. (1990). *The scientific literacy of Australian students: Science achievement of students in Australian primary and lower secondary schools.* ACER Research Monograph No. 39. ACER. Hawthorn, Victoria.

Rubba, P. & Anderson, H. (1978). Development of an instrument to assess secondary school students' understanding of the nature of scientific knowledge. *Science Education, 62,449 – 458.*

Sanders, M. (1999). *Implementing Outcomes-Based Education in South Africa – what lessons can science educators learn from classroom practitioners in New Zealand?* Proceedings of the 7th South African Association for Research in Mathematics, Science and Technology Education conference, Harare, January, 1999.

Schagen, S., & Kerr, D. (1999). *Bridging the gap?: The national curriculum and progression from primary to secondary school.* Slough: NFER.

Schibeci, R.A. (1984). Attitudes to Science: an update. *Studies in Science Education*, *11*, 26 – 59.

Schoeneberger, M. & Russell, T. (1986). Primary science as a little added frill: a report of two case studies. *Science Education, 70*(5), 519 – 538.

Schoon I, Ross A & Martin P 2007. Science related careers: aspirations and outcomes in two British cohort studies. *Equal Opportunities International, 26*, 129-143.

Schumaker, D. (1998).The transition to middle school. Champaign, IL: ERIC Clearinghouse on Elementary and Early Childhood Education.

Scott, A.W. (1989). In-service for primary teachers in science education: some directions for the future. *Research in Science Education.*

Secondary Science Curriculum Review. (1987). *Better science: Building primary–secondary links.* London: Heinemann.

Shrigley, R.L. (1974). The correlation of science attitude and science knowledge of preservice primary teachers. *Science Education, 58*(2), 143 – 151.

Shrigley, R.L. (1977). The function of professional reinforcement in supporting a more positive attitude of primary teachers toward science. *Journal of Research in Science Teaching, 14*(4), 317 – 322.

Simmons, R.G. & Blyth, D.A. (1987). *Moving into adolescence: The impact of pubertal change and school context.* Hawthorne, NY: Aldine de Gruyter.

Skinner, R.R. (1987). Intergrated Science versus Separate Sciences: How SCISP compares at O-level and as a preparation for A-level. Ph.D thesis. London: King's College of London, Centre for Educational Studies.

Smith, D.C. & Neale, D.C. (1989). The construction of subject matter knowledge in primary science teaching. *Teaching and Teacher Education, 5*(1), 1- 20.

Snow, W.H., Gilchrist, L., Schilling, R.F., Schinke, S.P. & Kelso, C. (1986). Preparing students for the junior high school. *Journal of Early Adolescence, 6*(2), 127 – 137.

Songer, N.B. and Linn, M.C. (1991). How do students' views of science influence knowledge integration? *Journal of Research in Science Teaching, 28*, 761 – 784.

Speering, W and Rennie, L. (1996). Students' perceptions about science: The impact of transition from primary to secondary school. *Research in Science Education, 26*(3), 283 – 298.

Stats SA (Statistics South Africa). (2006) Labour Force Survey September 2005. Pretoria. <http://www.statssa.gov.za/PublicationsHTML/P0210September2005/html/P0210September2005.html> Accessed 03 January 2008.

Stoffels, N.T. (2004). "Sir on what page is the answer?" Exploring teacher decision-making in the context of complex curriculum reforms. Unpublished Ph.D thesis. Pretoria: University of Pretoria, South Africa.

Sullivan, R.J. (1979). Students' interest in specific science topics. *Science Education*, *63*, 591 – 598.

Swanepoel, C.H. (1986). Die aard en meting van standerd 7-leerlinge se belangstelling in die natuurwetenskaplike studierigting. D.Ed-proefskrif. Pretoria: University of South Africa.

Taylor, N. & Vinjevold, P. (1999). *Getting learning right:* Report of the President's Education Initiative Research Project. Johannesburg:Jet.

Tema, B. (1997). Classroom practice in OBE. *Jet Bulletin, 7*, 15 – 19.

The more things change, the more they remain the same (Plus ça change, plus c'est la même chose) attributed to Alphonse Karr (1808 – 1890), French journalist, novelist. Les Guepes (Paris, Jan. 31, 1849) from http://www.bartleby.com/66/88/32088.html. Accessed 18 May 2006.

Thutong: South Africa's education portal - www.thutong.org.za. www.southafrica.info. Accessed 30 June 2006.

Tilgner, P.J. (1990). Avoiding science in the primary school. *Science Education; 74*(4), 421 – 431.

Traxler, A.E. and North, R.D. (1966). *Techniques of guidance*. 3rd edition. New York: Harper and Row.

Tsai, C.C. (1998). An analysis of Taiwanese eighth graders' science achievement, scientific epistemological beliefs and cognitive structure outcomes after learning basic atomic theory. *International Journal of Science Education*, *20,* 413 – 425.

Van Der Vyver, J. (2000). From rote learning to meaningful learning. Education Practice. *The Journal of the Gauteng Department of Education*. Issue 5.

Viennot, L. (1979). Spontaneous reasoning in elementary dynamics. *European Journal of Science Education*, *1*, 205 - 221.

Vlaardingerbroek, B. and Ros, L. (1990). Educational transition rates and upper secondary students' ability in five developing countries. *Educational Studies in Mathematics 21*(5),451 – 460.

Wallace, J. & Louden, W. (1992). Science teaching and teachers' knowledge: prospects for reform of primary classrooms. *Science Education*, *76*(5), 507 – 521.

Ward, R. (2000). Transfer from middle to secondary school: a New Zealand study. *International Journal of Educational Research, 33*, 365 – 374.

Ward, B.A., Mergendoller, J.R., Tikunoff, W.J., Rounds, T.S., Mitman, A.L. & Dadey, G.J. (1982). *Junior high school transition study, Executive summary*, vol. VII. San Fransisco: Far West Laboratory for Educational Research and Development.

Wells, M.C. (1996). *Literacies lost: When students move from a progressive middle school to a traditional high school.* New York: Teachers College Press.

Weston, P., Lazonby, J. and Tomlins, B. (1994). *Progression to post-16 Chemistry: A Survey of Schools and Colleges.* Slough, U.K. National Foundation for Education Research.

White, R., Gunstone, R., Elterman, E., MacDonald, I., McKittrick, B., Mills, D. and Mulhall, P. (1995). Students' perceptions of teaching and learning in first year university physics. *Research in Science Education*, *25*(4), 465 – 478.

Yager, R.E. (1983). Elementary teachers – take a bow. *Science and Children, 20,* 20 –22.

Yeboah, D. A. (2002). Enhancing Transition from Early Childhood Phase to Primary Education: evidence from the research literature. *Early Years. 22* (1), 51 – 68.

Yin, R.K. (2003). *Applications of case study research*. London: Sage publications.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

APPENDIX A

For office use

INTEREST QUESTIONNAIRE FOR THE NATURAL SCIENCE FIELD OF STUDY (IQNSFS) – adapted from Swanepoel, C.H. (1986)

Respondent V1 ☐☐☐☐ 1

What is your surname?

What are your initials?

What is your gender?

Male	**1**	V2 ☐	5
Female	**2**		

For each item below, indicate to what extent you would like to practice the activity

Please use the code:

0	=	Would **N**ever do it
1	=	**D**on't like it, but may do it
2	=	Like it **S**lightly
3	=	Like it **V**ery much

	Item	N	D	S	V			
1	Make a model of the wiring of lights in a house	**0**	**1**	**2**	**3**	V3	☐	6
2	Determine the product of two algebraic fractions	**0**	**1**	**2**	**3**	V4	☐	7
3	Solve a problem by means of a computer in line with given nstructions	**0**	**1**	**2**	**3**	V5	☐	8
4	Watch a television programme on what happens to a light ray when it passes through Perspex	**0**	**1**	**2**	**3**	V6	☐	9
5	Determine the amount of work done in lifting up an object	**0**	**1**	**2**	**3**	V7	☐	10
6	Study the anatomy of a grasshopper	**0**	**1**	**2**	**3**	V8	☐	11
7	Find out if it is better to buy 24 small containers of cool drink than 6 large ones	**0**	**1**	**2**	**3**	V9	☐	12
8	Watch a television programme on the kinds of memories used in computers	**0**	**1**	**2**	**3**	V1	☐	13
9	Play mathematical games	**0**	**1**	**2**	**3**	V1	☐	14
10	Cultivate indigenous plants	**0**	**1**	**2**	**3**	V1	☐	15
11	Conduct an experiment to test for starch in a green Leaf	**0**	**1**	**2**	**3**	V1	☐	16

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

For each item below, indicate to what extent you would like to practice the activity

For office use

Please use the code:

0	=	Would **N**ever do it
1	=	**D**on't like it, but may do it
2	=	Like it **S**lightly
3	=	Like it **V**ery much

	Item	N	D	S	V			
12	Solve a geometry problem	**0**	**1**	**2**	**3**	V14		17
13	Demonstrate to others what a computer can do	**0**	**1**	**2**	**3**	V15		18
14	Find out how a hydraulic jack helps one to easily lift up a heavy car	**0**	**1**	**2**	**3**	V16		19
15	Establish by means of an experiment that carbon dioxide is given off during respiration in germinating seeds	**0**	**1**	**2**	**3**	V17		20
16	Find out the meaning of computer terms such as operating system, memory and software	**0**	**1**	**2**	**3**	V18		21
17	Study micro-organisms under a microscope	**0**	**1**	**2**	**3**	V19		22
18	Prove a given theorem	**0**	**1**	**2**	**3**	V20		23
19	Read about how a hydrogen bomb is made	**0**	**1**	**2**	**3**	V21		24
20	Find a suitable method of separating a mixture of salt and sand	**0**	**1**	**2**	**3**	V22		25
21	Listen to a presentation on how computers use Memory	**0**	**1**	**2**	**3**	V23		26
22	Try to cultivate a new species of potato	**0**	**1**	**2**	**3**	V24		27
23	Combine two elements to form a compound in a chemical process	**0**	**1**	**2**	**3**	V25		28
24	Study different computer programs	**0**	**1**	**2**	**3**	V26		29
25	Derive a formula in mathematics	**0**	**1**	**2**	**3**	V27		30
26	Study the life cycle of a parasite	**0**	**1**	**2**	**3**	V28		31
27	Learn to use a computer program	**0**	**1**	**2**	**3**	V29		32
28	Answer questions from a graph in mathematics	**0**	**1**	**2**	**3**	V30		33
29	Establish by means of an experiment the reaction of various metals with an acid	**0**	**1**	**2**	**3**	V31		34
30	Modify a computer program	**0**	**1**	**2**	**3**	V32		35
31	Divide learners into groups according to their Performance in a test	**0**	**1**	**2**	**3**	V33		36
32	Take part in a conversation about pressure changes when the depth or density of a liquid changes	**0**	**1**	**2**	**3**	V34		37
33	Watch a television program on the importance of water in nutrition	**0**	**1**	**2**	**3**	V35		38
34	Determine the height of a tall building	**0**	**1**	**2**	**3**	V36		39
35	Extract gold from gold ore	**0**	**1**	**2**	**3**	V37		40
36	Represent in a diagram the way a computer executes instructions	**0**	**1**	**2**	**3**	V38		41
37	Measure voltage in parallel and series circuits	**0**	**1**	**2**	**3**	V39		42

For each item below, indicate to what extent you would like to practice the activity

For office use

Please use the code:

0	=	Would **N**ever do it
1	=	**D**on't like it, but may do it
2	=	Like it **S**lightly
3	=	Like it **V**ery much

	Item	N	D	S	V		
38	Study how a bird's digestive system works	**0**	**1**	**2**	**3**	V40	43
39	Listen to a presentation on the fields in which a computer can be used	**0**	**1**	**2**	**3**	V41	44
40	Design a computer program to establish how many entries are required to win in the different levels of a lottery	**0**	**1**	**2**	**3**	V42	45
41	Read about the role of a liver in nutrition	**0**	**1**	**2**	**3**	V43	46
42	Take measurements of a house to determine if certain furniture can fit in	**0**	**1**	**2**	**3**	V44	47
43	Read an article on how to measure sound	**0**	**1**	**2**	**3**	V45	48
44	Demonstrate by means of an experiment the action of saliva on starch	**0**	**1**	**2**	**3**	V46	49
45	Conduct research on what nutrients will enable a fruit tree to bear the most fruit	**0**	**1**	**2**	**3**	V47	50
46	Write the instructions for a computer to solve a business problem	**0**	**1**	**2**	**3**	V48	51
47	Calculate what R500 will be worth in 25 years' time	**0**	**1**	**2**	**3**	V49	52
48	Study the operation of a camera	**0**	**1**	**2**	**3**	V50	53
49	Explain how a computer adds up two numbers	**0**	**1**	**2**	**3**	V51	54
50	Provide proof from a number of mathematical Data	**0**	**1**	**2**	**3**	V52	55
51	Calculate how many bricks are required to build a house	**0**	**1**	**2**	**3**	V53	56
52	Study theories on the cause of lightning	**0**	**1**	**2**	**3**	V54	57
53	Conduct experiments to determine the ideal temperature and humidity for a certain plant to blossom	**0**	**1**	**2**	**3**	V55	58
54	Explain to someone, step by step, how to write a letter using a computer.	**0**	**1**	**2**	**3**	V56	59
55	Study the characteristics of a newly discovered plant	**0**	**1**	**2**	**3**	V57	60
56	Determine by means of certain formulas how large the population of the country will be in 20 years' time.	**0**	**1**	**2**	**3**	V58	61
57	Verify the data in a computer printout	**0**	**1**	**2**	**3**	V59	62
58	Watch a TV program on the use of mathematics in everyday life	**0**	**1**	**2**	**3**	V60	63

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

For each item below, indicate to what extent you would like to practice the activity

For office use

Please use the code:

0 = Would **N**ever do it
1 = **D**on't like it, but may do it
2 = Like it **S**lightly
3 = Like it **V**ery much

	Item	N	D	S	V		
59	Study the effect of resistance in a circuit	**0**	**1**	**2**	**3**	V61	64
60	Use a formula using a computer	**0**	**1**	**2**	**3**	V62	65
61	Calculate the area of a floor to determine how many tiles are needed	**0**	**1**	**2**	**3**	V63	66
62	Help to prune trees in a nursery	**0**	**1**	**2**	**3**	V64	67
63	Do research on petrol from coal	**0**	**1**	**2**	**3**	V65	68
64	Establish with the aid of a computer the popularity of some politicians	**0**	**1**	**2**	**3**	V66	69
65	Watch a television program on the difference between a mainframe, mini- and microcomputers	**0**	**1**	**2**	**3**	V67	70
66	Calculate what it costs to build a school	**0**	**1**	**2**	**3**	V68	71
67	Dissect a rat to find out how its digestive system works	**0**	**1**	**2**	**3**	V69	72
68	Undergo training on computer programming	**0**	**1**	**2**	**3**	V70	73
69	Read an article on the effect of the moon on the Earth	**0**	**1**	**2**	**3**	V71	74
70	Investigate why windmills are often used as power pumps in South Africa	**0**	**1**	**2**	**3**	V72	75
71	Study the graph that shows the level of the blood sugar of a diabetic during a 12 hour period	**0**	**1**	**2**	**3**	V73	76
72	Set a question paper on mathematics	**0**	**1**	**2**	**3**	V74	77
73	Play games on a computer	**0**	**1**	**2**	**3**	V75	78
74	Put together the skulls of different animals for an exhibition	**0**	**1**	**2**	**3**	V76	79
75	Discuss how mathematics can be used in other Subjects	**0**	**1**	**2**	**3**	V77	80
76	Watch a television programme on how the behaviour of owls is observed	**0**	**1**	**2**	**3**	V78	81
77	Explain to someone how to use a voltmeter	**0**	**1**	**2**	**3**	V79	82
78	Correctly solve a problem using a method that your teacher did not teach you about	**0**	**1**	**2**	**3**	V80	83
79	Use the computer to teach a foreign language, such as German	**0**	**1**	**2**	**3**	V81	84
80	Determine the maximum force that can be exerted by a person's leg muscle	**0**	**1**	**2**	**3**	V82	85
81	Build a model to represent a water molecule					V83	86

For each item below, indicate to what extent you would like to practice the activity

For office use

Please use the code:

0 = Would **N**ever do it
1 = **D**on't like it, but may do it
2 = Like it **S**lightly
3 = Like it **V**ery much

	Item	N	D	S	V			
82	Do calculations with fractions	**0**	**1**	**2**	**3**	V84		87
83	Mark sea-birds to collect information on their migration and breeding habits	**0**	**1**	**2**	**3**	V85		88
84	Burn some elements in oxygen	**0**	**1**	**2**	**3**	V86		89

Thank you for your time, co-operation and participation in this Questionnaire

APPENDIX B

The FREQ Procedure

V2	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	183	43.88	183	43.88
2	234	56.12	417	100.00

V3	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	72	17.27	72	17.27
1	176	42.21	248	59.47
2	110	26.38	358	85.85
3	59	14.15	417	100.00

V4	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	66	15.83	66	15.83
1	140	33.57	206	49.40
2	163	39.09	369	88.49
3	48	11.51	417	100.00

V5	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	11	2.64	11	2.64
1	58	13.91	69	16.55
2	110	26.38	179	42.93
3	238	57.07	417	100.00

V6	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	37	8.87	37	8.87
1	109	26.14	146	35.01
2	168	40.29	314	75.30
3	103	24.70	417	100.00

V7	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	48	11.51	48	11.51
1	126	30.22	174	41.73
2	132	31.65	306	73.38
3	111	26.62	417	100.00

The FREQ Procedure

V8	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	77	18.47	77	18.47
1	131	31.41	208	49.88
2	120	28.78	328	78.66
3	89	21.34	417	100.00

V9	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	42	10.07	42	10.07
1	100	23.98	142	34.05
2	133	31.89	275	65.95
3	142	34.05	417	100.00

V10	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	12	2.88	12	2.88
1	50	11.99	62	14.87
2	88	21.10	150	35.97
3	267	64.03	417	100.00

V11	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	27	6.49	27	6.49
1	56	13.46	83	19.95
2	83	19.95	166	39.90
3	250	60.10	416	100.00

Frequency Missing = 1

V12	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	32	7.67	32	7.67
1	150	35.97	182	43.65
2	152	36.45	334	80.10
3	83	19.90	417	100.00

V13	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	62	14.87	62	14.87
1	140	33.57	202	48.44
2	134	32.13	336	80.58
3	81	19.42	417	100.00

The FREQ Procedure

V14	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	56	13.43	56	13.43
1	117	28.06	173	41.49
2	133	31.89	306	73.38
3	111	26.62	417	100.00

V15	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	13	3.12	13	3.12
1	48	11.51	61	14.63
2	121	29.02	182	43.65
3	235	56.35	417	100.00

V16	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	58	13.91	58	13.91
1	110	26.38	168	40.29
2	130	31.18	298	71.46
3	119	28.54	417	100.00

V17	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	55	13.19	55	13.19
1	127	30.46	182	43.65
2	132	31.65	314	75.30
3	103	24.70	417	100.00

V18	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	6	1.44	6	1.44
1	48	11.51	54	12.95
2	88	21.10	142	34.05
3	275	65.95	417	100.00

V19	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	27	6.47	27	6.47
1	70	16.79	97	23.26
2	110	26.38	207	49.64
3	210	50.36	417	100.00

The FREQ Procedure

V20	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	62	14.87	62	14.87
1	160	38.37	222	53.24
2	143	34.29	365	87.53
3	52	12.47	417	100.00

V21	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	29	6.95	29	6.95
1	92	22.06	121	29.02
2	93	22.30	214	51.32
3	203	48.68	417	100.00

V22	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	44	10.55	44	10.55
1	99	23.74	143	34.29
2	132	31.65	275	65.95
3	142	34.05	417	100.00

V23	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	8	1.92	8	1.92
1	28	6.71	36	8.63
2	83	19.90	119	28.54
3	298	71.46	417	100.00

V24	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	54	12.95	54	12.95
1	128	30.70	182	43.65
2	169	40.53	351	84.17
3	66	15.83	417	100.00

V25	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	48	11.51	48	11.51
1	133	31.89	181	43.41
2	120	28.78	301	72.18
3	116	27.82	417	100.00

The FREQ Procedure

V26	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	10	2.40	10	2.40
1	26	6.24	36	8.63
2	48	11.51	84	20.14
3	333	79.86	417	100.00

V27	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	35	8.39	35	8.39
1	118	28.30	153	36.69
2	121	29.02	274	65.71
3	143	34.29	417	100.00

V28	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	31	7.43	31	7.43
1	119	28.54	150	35.97
2	151	36.21	301	72.18
3	116	27.82	417	100.00

V29	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	7	1.68	7	1.68
1	29	6.95	36	8.63
2	53	12.71	89	21.34
3	328	78.66	417	100.00

V30	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	38	9.11	38	9.11
1	96	23.02	134	32.13
2	119	28.54	253	60.67
3	164	39.33	417	100.00

V31	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	86	20.62	86	20.62
1	133	31.89	219	52.52
2	144	34.53	363	87.05
3	54	12.95	417	100.00

The FREQ Procedure

V32	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	18	4.32	18	4.32
1	56	13.43	74	17.75
2	129	30.94	203	48.68
3	214	51.32	417	100.00

V33	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	63	15.11	63	15.11
1	70	16.79	133	31.89
2	107	25.66	240	57.55
3	177	42.45	417	100.00

V34	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	57	13.70	57	13.70
1	133	31.97	190	45.67
2	151	36.30	341	81.97
3	75	18.03	416	100.00

Frequency Missing = 1

V35	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	22	5.28	22	5.28
1	62	14.87	84	20.14
2	115	27.58	199	47.72
3	218	52.28	417	100.00

V36	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	49	11.75	49	11.75
1	110	26.38	159	38.13
2	159	38.13	318	76.26
3	99	23.74	417	100.00

V37	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	46	11.03	46	11.03
1	112	26.86	158	37.89
2	137	32.85	295	70.74
3	122	29.26	417	100.00

The FREQ Procedure

V38	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	21	5.04	21	5.04
1	78	18.71	99	23.74
2	114	27.34	213	51.08
3	204	48.92	417	100.00

V39	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	65	15.59	65	15.59
1	125	29.98	190	45.56
2	129	30.94	319	76.50
3	98	23.50	417	100.00

V40	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	38	9.11	38	9.11
1	113	27.10	151	36.21
2	122	29.26	273	65.47
3	144	34.53	417	100.00

V41	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	12	2.88	12	2.88
1	58	13.91	70	16.79
2	104	24.94	174	41.73
3	243	58.27	417	100.00

V42	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	21	5.04	21	5.04
1	66	15.83	87	20.86
2	116	27.82	203	48.68
3	214	51.32	417	100.00

V43	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	29	6.95	29	6.95
1	113	27.10	142	34.05
2	167	40.05	309	74.10
3	108	25.90	417	100.00

The FREQ Procedure

V44	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	47	11.27	47	11.27
1	133	31.89	180	43.17
2	122	29.26	302	72.42
3	115	27.58	417	100.00

V45	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	35	8.39	35	8.39
1	96	23.02	131	31.41
2	128	30.70	259	62.11
3	158	37.89	417	100.00

V46	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	70	16.79	70	16.79
1	162	38.85	232	55.64
2	133	31.89	365	87.53
3	52	12.47	417	100.00

V47	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	30	7.19	30	7.19
1	104	24.94	134	32.13
2	147	35.25	281	67.39
3	136	32.61	417	100.00

V48	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	25	6.00	25	6.00
1	52	12.47	77	18.47
2	115	27.58	192	46.04
3	225	53.96	417	100.00

V49	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	34	8.15	34	8.15
1	88	21.10	122	29.26
2	115	27.58	237	56.83
3	180	43.17	417	100.00

The FREQ Procedure

V50	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	40	9.59	40	9.59
1	89	21.34	129	30.94
2	128	30.70	257	61.63
3	160	38.37	417	100.00

V51	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	25	6.00	25	6.00
1	71	17.03	96	23.02
2	122	29.26	218	52.28
3	199	47.72	417	100.00

V52	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	55	13.22	55	13.22
1	114	27.40	169	40.62
2	128	30.77	297	71.39
3	119	28.61	416	100.00

Frequency Missing = 1

V53	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	80	19.18	80	19.18
1	94	22.54	174	41.73
2	130	31.18	304	72.90
3	113	27.10	417	100.00

V54	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	60	14.39	60	14.39
1	133	31.89	193	46.28
2	130	31.18	323	77.46
3	94	22.54	417	100.00

V55	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	78	18.71	78	18.71
1	144	34.53	222	53.24
2	143	34.29	365	87.53
3	52	12.47	417	100.00

The FREQ Procedure

V56	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	17	4.08	17	4.08
1	46	11.03	63	15.11
2	86	20.62	149	35.73
3	268	64.27	417	100.00

V57	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	47	11.27	47	11.27
1	125	29.98	172	41.25
2	158	37.89	330	79.14
3	87	20.86	417	100.00

V58	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	39	9.35	39	9.35
1	110	26.38	149	35.73
2	149	35.73	298	71.46
3	119	28.54	417	100.00

V59	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	23	5.52	23	5.52
1	88	21.10	111	26.62
2	146	35.01	257	61.63
3	160	38.37	417	100.00

V60	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	49	11.75	49	11.75
1	82	19.66	131	31.41
2	98	23.50	229	54.92
3	188	45.08	417	100.00

V61	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	61	14.63	61	14.63
1	153	36.69	214	51.32
2	128	30.70	342	82.01
3	75	17.99	417	100.00

The FREQ Procedure

V62	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	18	4.32	18	4.32
1	53	12.71	71	17.03
2	95	22.78	166	39.81
3	251	60.19	417	100.00

V63	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	50	11.99	50	11.99
1	124	29.74	174	41.73
2	119	28.54	293	70.26
3	124	29.74	417	100.00

V64	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	76	18.23	76	18.23
1	139	33.33	215	51.56
2	143	34.29	358	85.85
3	59	14.15	417	100.00

V65	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	54	12.95	54	12.95
1	125	29.98	179	42.93
2	134	32.13	313	75.06
3	104	24.94	417	100.00

V66	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	51	12.23	51	12.23
1	123	29.50	174	41.73
2	118	28.30	292	70.02
3	125	29.98	417	100.00

V67	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	36	8.63	36	8.63
1	87	20.86	123	29.50
2	131	31.41	254	60.91
3	163	39.09	417	100.00

The FREQ Procedure

V68	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	47	11.27	47	11.27
1	93	22.30	140	33.57
2	130	31.18	270	64.75
3	147	35.25	417	100.00

V69	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	72	17.27	72	17.27
1	129	30.94	201	48.20
2	144	34.53	345	82.73
3	72	17.27	417	100.00

V70	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	21	5.04	21	5.04
1	52	12.47	73	17.51
2	93	22.30	166	39.81
3	251	60.19	417	100.00

V71	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	24	5.76	24	5.76
1	95	22.78	119	28.54
2	129	30.94	248	59.47
3	169	40.53	417	100.00

V72	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	29	6.95	29	6.95
1	86	20.62	115	27.58
2	155	37.17	270	64.75
3	147	35.25	417	100.00

V73	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	42	10.07	42	10.07
1	96	23.02	138	33.09
2	146	35.01	284	68.11
3	133	31.89	417	100.00

The FREQ Procedure

V74	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	68	16.31	68	16.31
1	102	24.46	170	40.77
2	102	24.46	272	65.23
3	145	34.77	417	100.00

V75	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	9	2.16	9	2.16
1	33	7.91	42	10.07
2	49	11.75	91	21.82
3	326	78.18	417	100.00

V76	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	48	11.51	48	11.51
1	145	34.77	193	46.28
2	152	36.45	345	82.73
3	72	17.27	417	100.00

V77	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	50	11.99	50	11.99
1	89	21.34	139	33.33
2	123	29.50	262	62.83
3	155	37.17	417	100.00

V78	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	68	16.31	68	16.31
1	105	25.18	173	41.49
2	142	34.05	315	75.54
3	102	24.46	417	100.00

V79	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	72	17.27	72	17.27
1	136	32.61	208	49.88
2	133	31.89	341	81.77
3	76	18.23	417	100.00

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

The FREQ Procedure

V80	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	59	14.15	59	14.15
1	122	29.26	181	43.41
2	118	28.30	299	71.70
3	118	28.30	417	100.00

V81	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	30	7.19	30	7.19
1	62	14.87	92	22.06
2	109	26.14	201	48.20
3	216	51.80	417	100.00

V82	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	49	11.75	49	11.75
1	156	37.41	205	49.16
2	146	35.01	351	84.17
3	66	15.83	417	100.00

V83	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	61	14.63	61	14.63
1	115	27.58	176	42.21
2	143	34.29	319	76.50
3	98	23.50	417	100.00

V84	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	60	14.39	60	14.39
1	107	25.66	167	40.05
2	124	29.74	291	69.78
3	126	30.22	417	100.00

V85	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	56	13.43	56	13.43
1	141	33.81	197	47.24
2	153	36.69	350	83.93
3	67	16.07	417	100.00

The FREQ Procedure

V86	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	63	15.11	63	15.11
1	114	27.34	177	42.45
2	118	28.30	295	70.74
3	122	29.26	417	100.00

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

For office use

APPENDIX C

NATURE OF SCIENTIFIC KNOWLEDGE SCALE QUESTIONNAIRE (NSKS) –(Rubba & Andersen , 1978

Respondent

V1 1

What is your surname?

What are your initials?

What is your gender?

Male	**1**	V2	3
Female	**2**		

For each item below, indicate to what extent you agree or disagree

Please use the code:

SA = *Strongly agree*
A = *Agree*
N = *Neutral*
D = *Disagree*
SD = *Strongly disagree*

	Item	RESPONSE						
1	Scientific laws, theories and concepts do not Express creativity	**SA**	**A**	**N**	**D**	**SD**	V3	4
2	Scientific knowledge is stated as simply as possible	**SA**	**A**	**N**	**D**	**SD**	V4	5
3	The laws, theories and concepts of biology, chemistry and physics are related	**SA**	**A**	**N**	**D**	**SD**	V5	6
4	The applications of scientific knowledge can be judged good or bad; but the knowledge itself cannot.	**SA**	**A**	**N**	**D**	**SD**	V6	7
5	It is incorrect to judge a piece of scientific knowledge as being good or bad	**SA**	**A**	**N**	**D**	**SD**	V7	8
6	If two scientific theories explain a scientist's chosen. observations equally well, the simpler theory is chosen	**SA**	**A**	**N**	**D**	**SD**	V8	9
7	Certain pieces of scientific knowledge are good and others are bad	**SA**	**A**	**N**	**D**	**SD**	V9	10
8	Even if the applications of a scientific theory are judged to be good, we should not judge the theory itself.	**SA**	**A**	**N**	**D**	**SD**	V10	11
9	Scientific knowledge need not be capable of experimental test.	**SA**	**A**	**N**	**D**	**SD**	V11	12
10	The laws, theories and concepts of biology, chemistry and physics are not linked.	SA	A	N	D	SD	V12	13
11	Consistency among test results is not a requirement for the acceptance of scientific knowledge.	**SA**	**A**	**N**	**D**	**SD**	V13	14

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

For each item below, indicate to what extent you agree or disagree

Please use the code:

SA	=	*Strongly agree*
A	=	*Agree*
N	=	*Neutral*
D	=	*Disagree*
SD	=	*Strongly disagree*

	Item	RESPONSE							
12	A piece of scientific knowledge will be accepted if the evidence can be obtained by other investigators working under similar conditions.	**SA**	**A**	**N**	**D**	**SD**	V14		15
13	The evidence for scientific knowledge need not be open to public examination	**SA**	**A**	**N**	**D**	**SD**	V15		16
14	Scientific laws, theories and concepts are not stated as simply as possible.	**SA**	**A**	**N**	**D**	**SD**	V16		17
15	There is an effort in science to build as great a number of laws, theories and concepts as possible.	**SA**	**A**	**N**	**D**	**SD**	V17		18
16	We accept scientific knowledge even though it may contain error.	**SA**	**A**	**N**	**D**	**SD**	V18		19
17	Scientific knowledge expresses the creativity of Scientists	**SA**	**A**	**N**	**D**	**SD**	V19		20
18	Moral judgement can be passed on scientific Knowledge	**SA**	**A**	**N**	**D**	**SD**	V20		21
19	The laws, theories and concepts of biology, chemistry and physics are not related	**SA**	**A**	**N**	**D**	**SD**	V21		22
20	Scientific laws, theories and concepts express creativity.	**SA**	**A**	**N**	**D**	**SD**	V22		23
21	It is meaningful to pass moral judgement on both the applications of scientific knowledge and the knowledge itself.	**SA**	**A**	**N**	**D**	**SD**	V23		24
22	The evidence for scientific knowledge must be Repeatable	**SA**	**A**	**N**	**D**	**SD**	V24		25
23	Scientific knowledge is not a product of human imagination.	**SA**	**A**	**N**	**D**	**SD**	V25		26
24	Relationships amongst the laws, theories and concepts of science do not contribute to the explanatory and predictive power of science.	**SA**	**A**	**N**	**D**	**SD**	V26		27
25	The truth of scientific knowledge is beyond doubt.	**SA**	**A**	**N**	**D**	**SD**	V27		28
26	Today's scientific laws, theories and concepts may have to be changed in the face of new evidence.	**SA**	**A**	**N**	**D**	**SD**	V28		29
27	We do not accept a piece of scientific knowledge unless it is free of error	**SA**	**A**	**N**	**D**	**SD**	V29		30
28	A scientific theory is similar to work of art in that both express creativity	**SA**	**A**	**N**	**D**	**SD**	V30		31
29	There is an effort in science to keep the number of laws, theories and concepts to a minimum.	**SA**	**A**	**N**	**D**	**SD**	V31		32

For each item below, indicate to what extent you agree or disagree

Please use the code:

SA	=	*Strongly agree*
A	=	*Agree*
N	=	*Neutral*
D	=	*Disagree*
SD	=	*Strongly disagree*

	Item	RESPONSE							
30	The various sciences contribute to a single organised body of knowledge.	SA	A	N	D	SD	V32		33
31	Scientific beliefs do not change over time	SA	A	N	D	SD	V33		34
32	Scientific knowledge is a product of human Imagination	SA	A	N	D	SD	V34		35
33	The evidence for a piece of scientific knowledge does not have to be repeatable.	SA	A	N	D	SD	V35		36
34	Scientific knowledge does not express the creativity of scientists.	SA	A	N	D	SD	V36		37
35	Biology, chemistry and physics are similar kinds of knowledge.	SA	A	N	D	SD	V37		38
36	If the applications of a piece of scientific knowledge are generally considered bad, then the piece of scientific knowledge is also considered to be bad.	SA	A	N	D	SD	V38		39
37	Scientific knowledge is subject to review and change.	SA	A	N	D	SD	V39		40
38	Scientific laws, theories and concepts are tested against reliable observations.	SA	A	N	D	SD	V40		41
39	If two scientific theories explain a scientist's observations equally well, the more complex theory is chosen.	SA	A	N	D	SD	V41		42
40	Scientific knowledge is specific as opposed to comprehensive	SA	A	N	D	SD	V42		43
41	Scientific theories are discovered, not created by man.	SA	A	N	D	SD	V43		44
42	Those scientific beliefs that were accepted in the past and have since been discarded should be judged in their historical context.	SA	A	N	D	SD	V44		45
43	Scientific knowledge is unchanging.	SA	A	N	D	SD	V45		46
44	Biology, chemistry and physics are different kinds of knowledge.	SA	A	N	D	SD	V46		47
45	Consistency amongst test results is a requirement for the acceptance of scientific knowledge.	SA	A	N	D	SD	V47		48
46	Scientific knowledge is comprehensive as opposed to specific.	SA	A	N	D	SD	V48		49
47	The laws, theories and concepts of biology, chemistry and physics are interwoven.	SA	A	N	D	SD	V49		50
48	A piece of scientific knowledge should not be judged good or bad.	SA	A	N	D	SD	V50		51

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

APPENDIX D

DIAGNOSTIC TEST (adapted from Novick & Menis, 1976).

SURNAME:__________________________ DATE__________________

FIRST NAME:________________________ AGE:__________

SEX: (MALE/FEMALE)___________

GRADE 11 DURATION: 30 Min

NOTE: 1. Pocket calculators may be used.

2. This test does not contribute to your overall year-mark.

INSTRUCTIONS:

1. Relax and answer ALL questions.

2. All the questions must be answered in this ANSWER BOOK.

3. Rough work must be indicated as such and may be done on the last few blank pages AT THE END OF THE ANSWER BOOK.

4. A Periodic Table is given.

5. Explain or show how you arrived at your answer in the space provided. Also indicate your level of confidence (i.e. how sure you are that your answer is correct) in the space provided. Example:

Indicate your level of confidence (how sure are you that you are correct?)

0%	50%	100%

6. Determine your level of confidence as follows:

6.1 If you simply do not know how to solve the problem or you find it too difficult to solve, indicate your level of confidence as 0%

6.2 If you think that you fully understand the question and that your method of solving the problem is reasonable but still not sure if you have the right answer, indicate your level of confidence as 50%.

6.3 If you are definitely sure of the answer, or you are sure that you have correctly worked out the answer, then you are 100% sure of the correct answer!

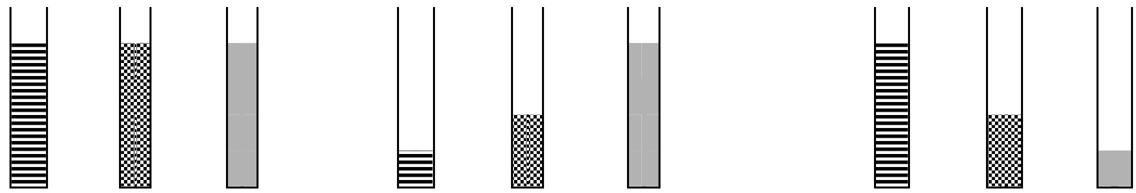
7. Hand in the answer book at the end.

-------------------------------------- GOOD LUCK!------------------------------------

QUESTION 1

Which of these three sets best shows 1 mole of tin, 1 mole of magnesium and 1 mole of sulphur in each tube.

Set 1 | Set 2 | Set 3



(a) (b) (c) | (a) (b) (c) | (a) (b) (c)

(a) - tin
(b) - magnesium
(c) - sulphur

key: Set 1 - equal volumes
Set 2 - equal masses
Set 3 - equal number of atoms

Give a reason/s for your answer below:

Indicate your level of confidence (how sure are you that you are correct?)

0%	50%	100%

QUESTION 2

Each container represents a volume of 22,4*l* at S.T.P. In which of the three pairs of containers, if any, is there one mole in each container?

red containers		blue containers		green containers	
$N_{2(g)}$	$H_{2(g)}$	$O_{2(g)}$	$Hg_{(l)}$	$SO_{2(g)}$	$S_{(s)}$

Write your answer below. Give reasons for your choice as well as for not choosing others.

Indicate your level of confidence (how sure are you that you are correct?)

0%	50%	100%

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

APPENDIX E

CLASSROOM OBSERVATION (adapted from ELRC, 2003)

Performance standard 1: Knowledge of curriculum and learning programmes

Expectation: The educator possesses appropriate content knowledge that is demonstrated in the creation of meaningful learning experiences

Question: does the educator demonstrate adequate knowledge of the Natural Science learning area or Physical Science subject and does s/he use this knowledge effectively to create meaningful experiences for learners in grade 9/10?

CRITERIA: (a) Knowledge of learning area/subject (b) skills (c) goal setting (d) involvement in learning programmes

Levels of performance	
1	Unacceptable
(a)	Educator conveys inaccurate and limited knowledge of learning area/subject
(b)	No skill in creating enjoyable learning experiences for learners
(c)	Little or no evidence of goal-setting to achieve curriculum outcomes
(d)	Makes no attempt to interpret the learning programmes for the benefit of learners
2	Satisfies minimum expectations
(a)	Educator's knowledge is adequate but not comprehensive.
(b)	Has some skill in engaging learners and relating the learning programme to learners' needs.
(c)	Evidence of some goal setting to achieve curriculum outcomes
(d)	Makes some attempt to interpret the learning programmes for the benefit of learners
3	Good
(a)	Educator is able to use knowledge and information to extend the knowledge of learners
(b)	Educator skilfully involves learners in learning area
(c)	Makes every endeavour to set realistic goals to achieve curriculum outcomes
(d)	Displays great enthusiasm in interpreting learning programmes in the interest of learners
4	Outstanding
(a)	Educator uses knowledge to diagnose learner strengths and weaknesses in order to develop teaching strategies
(b)	Educator uses learner-centred techniques that provide for acquisition of basic skills and knowledge and promotes critical thinking and problem solving
(c)	Curriculum outcomes are always achieved by being creative and innovative in the setting of goals
(d)	Excellent balance between clarity of goals of learning programmes and expression of learner needs, interests and background

APPENDIX E (Continued)

CLASSROOM OBSERVATION

Performance standard 2: Lesson planning, preparation and presentation

Expectation: The educator demonstrates competence in planning preparation, presentation and management of learning programmes

Question: Is lesson planning clear, logical and sequential and is there evidence that individual lessons fit into a broader learning programme?

CRITERIA: (a) Planning (b) Presentation (c) Recording (d) Management of learning programmes

Levels of performance	
1	Unacceptable
(a)	Little or no evidence of lesson planning
(b)	Lesson not presented clearly
(c)	No records are kept
(d)	Learners not involved in lessons in a way that supports their needs and the development of their skills and knowledge
2	Satisfies minimum expectations
(a)	Lesson planning not fully on a professional standard
(b)	Lessons are structured and relatively clearly presented
(c)	Evidence of essential records of planning and learner progress is available
(d)	Evidence of some learner involvement in lessons in a way that it supports their needs and the development of their skills and knowledge
3	Good
(a)	Lesson planning is generally clear, logical and sequential
(b)	Lessons are well structured and fit into the broader learning programme building on previous lessons and anticipating future learning activities
(c)	Essential records of planning and learning progress are maintained at a high level of proficiency
(d)	Good involvement of learners in lessons in such a way that it supports their needs and the development of their skills and knowledge

4	Outstanding
(a)	Lesson planning is abundantly clear, logical, sequential and developmental
(b)	Outstanding planning of lessons that are exceptionally well structured and clearly fits into the broader learning programme with evidence that it builds on previous lessons as well as fully anticipating future learning activities
(c)	Outstanding record keeping of planning and learner progress
(d)	Excellent involvement of learners in lessons in such a way that it fully supports their needs and the development of their skills and knowledge

APPENDIX F

GRADE 10 LESSON PLAN(DoE, 2006(b))

KNOWLEDGE AREA: CHEMICAL CHANGE		THEME	
DATE		Physical and Chemical change Representing chemical change	
DURATION			
CORE CONCEPTS			
LEARNING OUTCOMES		LO 1: Practical Scientific Inquiry and Problem solving skills	
		LO2: Constructing and applying Scientific knowledge	
		LO3: The Nature of Science and its relationship to Technology, Society and the Environment	

ASSESSMENT STANDARDS		
1.1	Conducting an investigation	
1.2	Interpreting data to draw conclusions	
1.3	Solving problems	
1.4	Communicating and presenting information and scientific arguments	
2.1	Recalling and stating specified concepts	
2.2	Indicating and explaining relationships	
2.3	Applying scientific knowledge	
3.1	Evaluating knowledge claims and science's inability to stand in isolation from other fields	
3.2	Evaluating the impact of science on human development	
3.3	Evaluating science's impact on the environment and sustainable development	

TEACHING ACTIVITIES

TEACHING METHODS				
Other:	Explanation		Practical demonstration	
	Jigsaw assignment		Practical group work	
	Debate		Reading time	
	Report back		Problem solving	
	Field trip		Viewing multi-media	

INTERGRATION		SKILLS		VALUES & ATTITUDES	
Mathematics		Classifying & communicating		Team work	
Math. Literacy		Critical thinking & problem solving		Appreciation	
Life Sciences		Drawing conclusions		Co-operation	
Life Orientation		Identifying and controlling variables		Responsibility	
Geography		Evaluating conclusions		Accountability	
Business Studies		Hypothesising		Empathy	
Civil Technology		Measuring		Self-esteem	
Electrical Technology		Observing & comparing		Endurance	
Mechanical Technology		Predicting			

APPENDIX F (Continued)

EXPANDED OPPORTUNITIES				**LTSM**	
Provide extra time for the slower learner				Laboratory equipment	
Provide large print reading for learner with visual problems				Projector/Blackboard	
Individual attention				Mult-media	
Study method assistance				Specialist guide (workbook)	
Extra work and reading material for advanced learners					
ASSESSMENT FORMS				**ASSESSMENT TOOLS**	
Daily assessment		**Formal assessment**		Rubric	
Test		Practical		Memo	
Practical work		Control Test			
Research assignment		Research project		**Method of assessment**	
Homework assignment		Exam		Self	
				Peer/group	
				Teacher	

APPENDIX G: GRADE 10 PHYSICAL SCIENCE (NCS) (Hand-out from DoE, 2006(b))

<table>
<tr><th>MECHANICS 12,5%</th><th>WAVES, SOUND AND LIGHT 12,5%</th></tr>
<tr><td>▪ <u>Motion in one dimension:</u>
• position, displacement, distance;
• speed, average velocity, instantaneous velocity;
• acceleration;
• description of motion in words, diagrams, graphs and equations;
• frames of reference.

▪ <u>Gravity and mechanical energy:</u>
• weight (force exerted by the earth on an object);
• acceleration due to gravity (acceleration resulting from the force exerted by the earth);
• gravitational potential energy;
• kinetic energy;
• mechanical energy (sum of gravitational potential energy and kinetic energy);
• conservation of mechanical energy (in the absence of dissipative forces)</td><td>▪ Transverse pulses on a string or spring:
• pulse length, amplitude, speed;
• graphs of particle position, displacement, velocity, acceleration;
• transmission and reflection at a boundary between two springs (or strings);
• relation of pulse speed to medium;
• reflection from a fixed end and a free end;
• superposition.

▪ <u>Transverse waves:</u>
• wavelength, frequency, amplitude, period, wave speed;
• particle position, displacement, velocity, acceleration;
• standing waves with rent boundary conditions (free and fixed end) as a kind of superposition.

▪ <u>Geometrical optics:</u>
• light rays;
• reflection;
• refraction (change of wave speed in different media);
• mirrors;
• total internal reflection, fibre optics in endoscopes and telecommunications.</td></tr>
<tr><th>ELECTRICITY AND MAGNETISM 12,5%</th><th>CHEMICAL CHANGE
18,75%</th></tr>
<tr><td><u>Magnetism:</u>
• magnetic field of permanent magnets;
• poles of permanent magnets, attraction and repulsion;
• Earth's magnetic field, compass.

▪ <u>Electrostatics:</u>
• two kinds of charge;
• force between charges (descriptive);
• attraction between charged and uncharged objects (polarisation);
• conductors and insulators.

▪ <u>Electric circuits:</u>
• need for a closed circuit for charges to flow;
• electrical potential difference (voltage);
• current;
• resistance;
• principles and instruments of measurement of voltage (P.D.), current and resistance.</td><td>▪ <u>Physical and Chemical Change</u>
• Microscopic interpretation of macroscopic changes (for example changes in conductivity and temperature)
• Separation of particles in decomposition and synthesis reactions
• Conservation of atoms and mass.
• Law of constant composition
• Conservation of energy
• Volume relationships in gaseous reactions.

▪ <u>Representing chemical change</u>
• Balanced chemical equations</td></tr>
</table>

APPENDIX G (Continued)

MATTER AND MATERIALS 25 %	CHEMICAL SYSTEMS 18,75 %
▪ **<u>Observing, describing, classifying and using materials - a macroscopic view</u>** • The material(s) of which an object is composed. • Mixtures: heterogeneous and homogeneous. • Pure substances: elements and compounds. • Names and formulae of substances. • Metals, semimetals and nonmetals. • Electrical conductors, semiconductors and insulators. • Thermal conductors and insulators. • Magnetic and nonmagnetic materials. ▪ **<u>Particles substances are made of</u>** • Atoms and molecules (simple and giant) • Linking macroscopic properties of materials to micro (particle) structure. • Intermolecular and intramolecular forces (chemical bonds). Physical state and density explained in terms of these forces. Particle kinetic energy and temperature. ▪ **<u>The Atom: basic building block of all matter</u>** • Models of the atom. • Atomic mass and diameter. • Structure of the atom: protons, neutrons, electrons. • Isotopes • Energy quantization and electron configuration. • Periodicity of ionization energy to support the arrangement of the atoms in the Periodic Table. • Successive ionization energies to provide evidence for the arrangement of electrons into core and valence electrons.	▪ **<u>Global cycles:</u>** <u>* The water cycle:</u> • Physical changes and energy transfers: The movement of water from the ocean and land surfaces as controlled by energy in sunlight. Reservoirs for water on Earth. • Macroscopic properties of the three phases of water related to their microscopic structure. <u>* The nitrogen cycle:</u> • Chemical changes and energy transfers. The movement of nitrogen between interrelated biological and geological systems. • Industrial fixation of nitrogen ▪ **<u>The hydrosphere</u>** * Its composition and interaction with other global systems. * Ions in aqueous solution: their interaction and effects. • Electrolytes and extent of ionization as measured by conductivity • Precipitation reactions.

APPENDIX H

Grade 10 Physical Science Lessons 1& 2 15 March 2006

Duration: 60 minutes

Teacher: Today we'll be talking about different .... and before we start we need to know that at the end of this lesson ... which ... or what we should be able to know: First when we end this lesson we should be able to know: **what is matter** (*writing on the chalkboard nervously*), we should be able to know what are **mixtures,** we should be able to know what are **elements**, we should be able to know what are **compounds, homogeneous mixtures**, and ... **heterogeneous mixtures**, we should be able to know **suspension.** These are the following concepts that we are going to deal with ... for this lesson of today (*pointing at the chalk board*).

Now, from previous classes I know that you have learned about what we call **matter**. What did we say **matter** was from previous classes?

Student: Matter is everything that occupies space and has mass
Teacher: Matter is everything or anything that occupies space ... and has mass (*as he writes on the chalkboard*) So, in chemistry study, we'll be studying about the matters ... we'll be studying about anything that occupies space and has mass and how they change. For instance: substances have a certain composition ... we differentiate them according to how they react. We have what we call **element**, **compound** and **mixtures** (*writes again on the board*). As we start, the elements, they are those substances that cannot be broken down into simpler substances; we cannot be able to separate them by physical means or by chemical means. Mixtures are substances that we can physically separate. For instance – air is a mixture; it's a mixture of hydrogen and oxygen; so we can be able to separate them. Even the compounds – compounds we can be able to separate them by (*into*) smaller particles.

Let's take examples of mixtures. Let's start with mixtures: If I take salt and mix it with water (*writes on the board*). I'm going to have a what? I am going to have a mixture! *Not so?*
Students (in chorus): Yes!
Teacher: And that mixture is called a clear mixture because water and salt can completely dissolve inside the what?
Students (in chorus with the teacher): Water!
Teacher: By virtue of the fact that water has ... mixed completely we say that the mixture is clear. There are some other elements that you are going to learn about, like copper sulphate. Copper sulphate is ... a colour. Although it has a colour, it can completely (*got stuck*) ... we call it a clear ... it is clear because although it has colour, but it can dissolve inside the water. Not so!
Students (in chorus): Yes
Teacher: Let us further move on to what we call homogeneous mixtures. Homogeneous mixtures, as I have made an example of water and salt, they are able to dissolve inside each other. But heterogeneous mixtures; let's say you take sand and mix it with what; with irons (iron filings). Can they completely mix?

Students (in chorus): No
Teacher: Why?
One student: They are both solids
Another student: One cannot dissolve in the other

Teacher: They are both solids. One cannot dissolve in the other (*repeating what the students said*). And if I were to take a magnet, would I be able to separate the sand from the iron filings?
Students (in chorus): Yes
Teacher: So, then, heterogeneous mixtures are mixtures of substances that cannot completely mix with each other. Number two – **suspension** (*writes it again on the board*). Let's say you mix sand with water, and then you stir it. What is going to happen?
Student: (*Inaudible)*
Teacher: Can you say that it will dissolve. Dissolve in water?
Students (in chorus): No
Teacher: It does not dissolve in water. So, if you were to take the very same container and put sand inside and mix it with ... *water*, it will definitely not dissolve in water but for us to have this suspension, I can be able to separate sand particles from water. I can use my container together with my funnel and filter paper. If I use my funnel to separate the water from the sand ... I will be able to separate the water and the sand. What will be left here on the filter paper will be the sand (*pointing to the drawing on the chalkboard).* Not so! And the sand ... we call it the **residue.** Let us take examples ..., a practical example of everyday that we see of homogeneous mixtures and heterogeneous mixtures. Let's start with homogeneous mixtures; number one:
I said a combination of hydrogen and oxygen, what does it give us; It gives us **water**. Can you see what was hydrogen, what was oxygen?

Students (in chorus): No!
Teacher: It is a homogeneous mixture. **Water** is an example of a **homogeneous mixture** because you cannot be able to see. Give me more examples of homogeneous mixtures that you see everyday.
Student: A coffee and hot water
Teacher: Mmmm... she is saying a coffee and hot water. Is it a homogeneous mixture?
Students: (*some say yes and others say no)*
Teacher: I agree with her. Coffee in a hot water is an example of a homogeneous mixture (*writes on the chalkboard*). Come with your own examples (*calls a few students by name and urges them to answer*)
One student: Water and Sweet Aid (*A popular drink*)
Teacher: Water and Sweet Aid is an example of homogeneous mixture (*writes on the board*). *When we come to* the examples of heterogeneous mixtures. Heterogeneous mixtures: inside a can of aerosol, there are two substances; what are the two substances; it's a combination of a gas and a liquid. There are three phases of matter, gas, liquid and solid. So, a homogeneous mixture is a combination of a gas and liquid in a form of a spray. Some of us Ego and others use Shield – these are examples of a homogeneous mixture. Before we go any further, are there any questions?
Student: In examples of homogeneous mixtures, do we always use water? Can you give an example without using water?
Teacher: Remember we have three phases of matter; it's either you can be able to mix liquid and solid or solid solid ... any example that will be able to be soluble ... that will combine completely ... remember homogeneous are those that can combine completely without eh ... in other words they are soluble ... they combine and they don't ... but homogeneous are those that cannot be separated easily ... yes my girl (*diverting attention to another student who had just raised her hand*).
Student: ... how do you separate them?

Teacher: You can separate them through chemical means. Let's take an example of water and salt. If you heat the solution for a long time, the salt will remain inside the container.
(There were sustained grumblings from the learners. Then there was a question from a student that was inaudible. The teacher ruled it irrelevant to the subject matter).

Now; I have examples here; I want you together with your partner to separate them into homogeneous and heterogeneous (*he wrote on the chalkboard: ink, milk, salt and water, tea, sand and water. The teacher then went around the class checking on learners as they went through the class work. The class was very rowdy. Towards the end of the period, he gave learners some homework: he asked them to look for five different products at home and identify their components from the labels, their % composition and then classify the components as solid, liquid or gas. Lastly they must state if they were harmful or not. That was the end of the lesson).*

In a repeat lesson in another classroom, he added the concept of **emulsions.**

APPENDIX I:

Grade 10 Physical Science Lessons 7 & 8 Date: 12 May 2006

Duration: 60 minutes

Teacher: Mercury is liquid at room temperature. All metals except mercury are solids. They have high melting points. If you melt them in the end, they will melt. *(What the teacher writes on the chalkboard is given in bold)*

1. So, except for mercury, the **metals are solid**
2. Another property of metals that they share, that they are in common with, is that **metals are shiny**. Metals have a tendency of being shiny; they are easily polishable. You can be able to polish them.
3. **Metals are malleable** – now, malleable simply means that they can be able to bend, they can be able to ... make them into any shape that you want with them.
4. Metals are very strong hence we use them for heavy duties (*writes on the chalk board*). **Metals are good conductors of electricity**. It's quite obvious, although sometimes we never realise, that the cables that comes to our homes, are made of metals. They are made of silver and copper; but the ones that are on our televisions, our radios they made of copper – so they are good conductors of electricity.
5. **They are also good conductors of heat**. Inside our kettles we use steel; inside the pot that we use everyday there is steel ... therefore they conduct heat. They are good conductors of heat. *Very inaudible sentence.*

The combination of metals and the non-metals is what we call **metalloids**. The darker part of the Periodic Table are the **non-metals** (*pointing to the Periodic Table*). Number ... the line that goes ... number 15... no ... number 5 *(referring to the atomic number as he points to the Periodic Table)*, number 14 which is silicon, boron, silicon, arsenic ... eh ... antimony... eh ... tellurium, polonium, astatine ... they are all metalloids. If you look at ... on top of eh ... number 1 ... the number 1 element ... eh ... hydrogen ... it's also indicating it's also a non-metal. Lithium, beryllium, all this ... sodium, magnesium, all of this ... they are **metals**. They are all metals. Now, if ... what is the fun of learning these particular metals everyday? *(No answer from students).* We've got to know what their day-to-day use *is* – what do we use them *for*. How do we use them every day in our lives? How do we use sodium, how do we use magnesium in our every day life?

.

APPENDIX I (Continued)

We use different metals in our every day lives. So, we are going to look at the uses of some of those metals. Let us look at sodium. Sodium in conjunction with other metals – we use it everyday:

1. Sodium in conjunction with chloride gives us something that we use everyday. What do you think that is?

Student: Salt.

Teacher: Salt. Sodium plus chloride gives us a salt.

2. Sodium plus oxygen plus hydrogen gives us sodium hydro-oxide. *Inaudible.* Usually when our drains are blocked, we use it – caustic soda. We also use a variety of other elements – for instance, we use (number 3)
3. Lithium in conjunction with carbon: Lithium carbonate. We use lithium carbonate – what do we use it for? We use it in making drugs – by drugs I don't mean the bad ones. *Inaudible*. We use lithium carbonate for *metally ill patients*.
4. We use gold – what do we use gold for?

Student: Jewellery.

Teacher: Jewellery.

5. Titanium – we use it mostly to build aircraft. *Inaudible. We also use it in making batteries.*

We use most of these elements each and every day of our lives, without being aware that we are using them. So, every time you see them or taste, you must be curious about whether some of the elements you have learnt about are being used

At this stage the teacher circulated samples of sodium and magnesium through the class. Learners became very rowdy as they awaited their turn to see the samples. It took about 10- 15 minutes for the samples to be seen by all.

Teacher: Now, while you are looking at that, I have written some of the names here of the elements. You are going to do your investigation now over the weekend. I want it on Monday. You do it on the exam paper; we are going to file it for your portfolio.

You are going to investigate ... what is sodium hydrogen carbonate; you are going to look at which product contains sodium hydrogen carbonate and what you use that product for. There are six of those that you are going to look at.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

APPENDIX J: INTERVIEW TRANSCRIPTS

Liza Eddington

No	STATEMENT	Code
1	I: What is your favourite subject in the FET phase?	
2	S: If I may say… ehm… you said the FET phase?	
3	I: Grade 10, 11, 12	
4	S: … it has to be Life Science… because… eh …my career… the career that I'm following has to do with the things that we are told in Life Sciences … meaning that my career … I want to be a doctor … so I think that my career depends on it mostly.	-1
5	I: Is your interest in science declining, increasing or remaining the same as you move from GET to FET?	
6	S: Actually at the moment it is decreasing, but then I know that I will pull up again, but at the moment it is decreasing	-1
7	I: What would you say is the reason	
8	S: I think that the things I was told before, were not that hard than now… things are changing and getting more difficult and I'm getting used to that… and the changing of teachers … last year we were taught by teacher X now this year we are taught … they have changed teachers, so I was used to teacher X from grade 10 and 11 but now they have changed him and so I think that is my problem.	
9	I: OK. Coming to the teacher-student relationship, how do you compare your relationship with your science teacher in grade 7,8 and 9 with the relationship with your science teachers in grade 10, 11 and 12?	
10	S: In grade 7 to 9 it was very good, it was very good because as I said before I was very good in those subjects but now it's good but not that good. It's not good because of what I've just said.	-1
11	I: Is the way science taught in the FET phase meeting your expectations?	
12	S: Yes, it does, it does 'cause the things that they are teaching now are the things that I want to know more …. you know … that is my expectation.	+1
13	I: In your own words, how would you describe the transition from the GET phase to the FET phase focusing on the transition from the Natural Science to Physical Science	
14	S: I don't know…	
15	I: Are you saying that you are not able to describe it?	
16	S: Yes, that is what I'm saying	

No	STATEMENT	Code
17	I: Would you say it's the same or would you say it's different…	
18	S: It's very different, it's very different, because… things are now changing and being more difficult because … in grade 7, 8 and 9 things were simple then … you were learning simple stuff and you would understand easily, but in grade 10, 11, 12 theirs were a bit difficult but then … I think that's the way things should be, you know.	-1
19	I: Now, I would like you to answer questions on the diagnostic test that I gave you. In the first question, I wanted you to choose: 'Which of these three sets best shows 1 mole of tin, 1 mole of magnesium and 1 mole of sulphur in each tube'; and you chose set 2. Can you give reasons why you chose set 2?	
20	S: I chose set 2 because … Mg is higher than S or Sn, their masses are equal but their volumes … I thought they were not equal	-1
21	I: What do you understand by a mole?	
22	S: Actually nothing … nothing	-1
23	I: Ok. Let's come to the second question: Here you chose red containers. Can you give reasons why you chose red containers?	
24	S: I chose red containers because I thought that the … their volume, they were having the same volume	
25	I: All of them have the same volume … 22.4 dm^3 at S.T.P	
26	S: Oh, yeah! … I thought that … because nitrogen has 2 … 2 nitrogen and 2 hydrogen, so they will have 1 mole in each	0
27	I: Thank you	

Linda Epson

No	STATEMENT	Code
1	I: What is your favourite subject in the FET phase	
2	S: My favourite subject in the FET phase is Life Science	-1
3	I: Can you tell me why?	
4	S: Because in Life Science we learn more about human bodies … it teaches us about things that we don't know	
5	I: Ok. What career would you like to follow?	
6	S: Metro police.	-1
7	I: Can you give me the reason why?	
8	S: If you look at most people working in the Metro police, there are no females … it's mainly males. I like the Metro police a lot because…it teaches people a lot: if you are a woman, you are a woman	
9	I: Tell me: Is your interest in science declining, increasing or remaining the same as you move from the GET phase to the FET phase?	
10	S: No, it's decreasing, because in grade 9 it was better than this year, 'cause it's so difficult for me	-1
11	I: How do you compare your relationship with your science teachers in grade 7,8 and 9 with the relationship with your science teachers in grade 10, 11 and 12?	
12	S: The relationship that I have in grade 9, 10 teachers was not like the teacher I got now in grade 11 and 12 … *the one who teaches me now is better because he is also my class teacher … and we can talk … but it was difficult to approach the others … the present one is approachable*	+1
13	I: Ok. Is the way science taught in the FET phase meeting your expectations? … Is the way the teacher is teaching science in grade 10, 11 and 12 meeting your expectations … is it what you expected?	
14	S: No. *In grade 9 lessons were easier to follow, but in grades 10, 11 and 12 it's becoming more difficult.*	-1
15	I: In your own words, how would you describe the transition from the GET phase to the FET phase focusing on the transition from the Natural Science to Physical Science	

No	STATEMENT	Code
16	S: *I think Physical Science is difficult*	-1
17	I: Let's come to the diagnostic test that I gave you … please explain how you came to your answer. In the first question I asked you: 'Which of these three sets best shows 1 mole of tin , 1 mole of magnesium and 1 mole of sulphur in each tube?' and you chose set 2. Why?	
18	S: I chose set 2 because I saw .. eh.. equal volume, equal mass and equal number of atoms. Then I think it was the right answer.	-1
19	I: What do you understand by a mole?	
20	S: I understand that a mole … is something that … they use it mostly in Physical Science … maybe to describe … I think sulphur, magnesium … I think they are using chemical or electrical chemistry	-1
21	I: Ok … let's come to the last question: in this second question I asked you: 'Each container represents a volume of 22,4 *l* at S.T.P. In which of the three pairs of containers, if any, is there one mole in each container?'	
22	S: I chose the red container because I think the blue container and the green container are representing the S.T.P. containers	-1
23	I: Thank you	

Henry Els

No	STATEMENT	Code
1	I: Tell me, what is your favourite subject in the FET phase?	
2	S: It's Mathematics	-1
3	I: Why Mathematics	
4	S: Actually I have a passion with .. like playing with numbers and all that	
5	I: What career would you like to follow?	
6	S: I would like to follow computer sciences … since I found that …I have love for computers …then I decided that … let me rather choose a career which involves computers a lot.	-1
7	I: Is your interest in science declining, increasing or remaining the same as you move from the GET phase to the FET phase?	
8	S: It's declining.	-1
9	I: Can you give me reasons why?	
10	S: Basically, from the GET section… the teachers there … they were like … trying to explain most of the stuff … and we didn't like expect the way we are being taught now	
11	I: How do you compare the relationship with your science teachers in grade 7,8 and 9 with your relationship with your science teachers in grade 10, 11 and 12.	
12	S: It's different … because …from the early grades .. teachers try to make us have more love for science rather than the ones we have right now. In the FET section, they come to class, teach you and the other work is for you to do	-1
13	I: Ok. Is the way science taught in the FET phase meeting your expectations?	
14	S: No, it's not	-1
15	I: Can you explain?	
16	S: When you have to do certain parts, especially in chemistry … that's where you have to do experiments .. so you find out that the school does not have enough material to help us out .. so you end up doing the experiment as part of theory.	
17	I: In your own words, how do you describe the transition from the GET to the FET phase, focusing on the transition from Natural Science to Physical Science	

No	STATEMENT	Code
18	S: I would say it's more like going to university but you're still at school … in grade 9 we were told … grade 9 is like grade 12… the way we are being assessed …so… moving to grade 10 … was more like you were doing your first year … doing your first year in matric.	-1
19	I: Ok. Let's now come to the diagnostic test that I gave to you. You chose set 2. Can you explain why?	
20	S: Choosing set 2 … I had confusion dealing with chemistry. ..if they are having equal masses … then the number of moles must be equal … rather than sticking to: if they have equal volumes … equal volumes does not mean that they will always have equal number of moles … because you may find that one may be a solid while the other one is a gas.	0
21	I: Tell me – what do you understand by a mole?	
22	S: It's a certain quantity of a substance … whereby if you do an experiment … you have to consider how much you put in. The other way of putting it …it's like dealing with concentrations .. but …by moles we deal with … the quantity	0
23	I: Let's come to question 2… you gave, as your answer: the red containers have one mole in each. Why did you choose red container	
24	S: I chose it because … when in class we were doing .. balancing the equations … we were told that … in front of an element …the number in front represents … the coefficient .. represents the number of moles.. then .. if nitrogen gas and hydrogen gas … that would mean that … they have equal number of moles … meaning that … each one has one compared to the other containers	0
25	I: Let's take example… oxygen and mercury … explain why you didn't choose blue containers	
26	S: Since oxygen is a gas and mercury is a liquid, if both of them were put together, it wouldn't make one mole …since the other one is liquid … it's like if you put gas in water, eventually there will be a reaction between the two.	0
27	I: OK. Thank you very much.	

Hazel Planck

No	STATEMENT	Code
1	I: What is your favourite subject in the FET phase	
2	S: My favourite subject is Mathematics because in Mathematics we do more with figures … and you have to calculate … it's not all about cramming the notes you are given … you have to know your subject and you have to practice	-1
3	I: What career would you like to follow?	
4	S: I'd like to be an actuarial scientist, because as an actuarial scientist … it deals with figures and statistics, and you also have to engage with the community; get to know more about the … where the country is going in terms of its commercial/ financial status.	-1
5	I: Is your interest in science declining, increasing or remaining the same as you move from the GET phase to the FET phase?	
6	S: My interest in science is declining because in the FET phase it's more complicated. I think the work is more and you have to memorise all these terms. It's more work and the chemistry part … I like the chemistry part as I was doing grade 9 and grade 8 but as I got to grade 10 it was more difficult because there was a bit of change in the way it was taught and the way I understood it; and the other thing is that we don't have laboratory so we have to read the experiment from the text-book and cram it	-1
7	I: How do you compare your relationship with your science teachers in grade 7, 8 and 9 with your relationship with your science teachers in grade 10, 11 and 12.	
8	S: The relationship I have with my science teachers in grade 11 and 12 is more good because … we engage more … they guide us about our future … they do some kind of guidance in terms of career choices .. they tell us about our level of intelligence in terms of science and they tell us which career to follow … they give us a choice … whereas in grade 8 and 9 it was all about theory … they teach the subject but you do not know what you are going to do with it when you finish school.	+1
9	I: Is the way science taught in the FET phase meeting your expectations?	

No	STATEMENT	Code
10	S: No, it is not, because when I was in grade 8 and 9 we did a lot of experiments … science was more of a practical subject but as we get to grade 10 we get stories like a … things that we have to do like experiments … they are expensive and we can no longer do them …so science is now more like …you have to cram and … know terms by heart without actually seeing the things you are talking about.	-1
11	I: In your own words, how do you describe the transition, that is movement from the GET phase to the FET phase focusing on the transition from Natural Science to Physical Science	
12	S: Well … when you go to the FET phase … there is more work … it is more difficult. I think in the lower grades they prepared us for is change because we used to write assignments and we did a lot of essays - maybe about a page but when we get to FET we have to write about three pages or four pages … it is more work … but it is in a good way because in the GET we were prepared for that	-1
13	I: Now, Nonhlanhla, let's come to the diagnostic test that you wrote. It was based on the mole concept. Explain why you chose set 3.	
14	S: The reason why I chose set 3 …I looked at the beakers in terms of the volumes … the number of atoms which are in the beakers … so I looked at the beakers and then I compared set 1,2 and 3 … I looked at them in sequence …in set one they are full and they decrease again in set 2 and set 3 again … the beaker is still the same while the 3 beakers decreased	-1
15	I: Let's look now at the second question. In the second question: why did you choose red containers	
16	S: I chose red containers because … both elements are gases while in the blue containers you've got a liquid and you also have a solid (*pointing to sulphur in the green containers).* It's just because of the gases	+1
17	I: I see that you have 0% level of confidence – are you sure that you are correct?	

No	STATEMENT	Code
18	S: No, I am not sure that I'm correct – I just used common sense because here at school we are not actually taught … chemistry …. we do a lot of the Physics part …. the calculations …. Not the chemistry part because it includes experiments	
19	I: Thank you very much	

Howard Prins

No	STATEMENT	Code
1	I: What is your favourite subject in the FET phase?	
2	S: Science	+1
3	I: Will you explain why science?	
4	S: Because … in science … I'm very good in science but again it's a subject that I found very interesting and which I wanted to pursue later on in future	
5	I: What career would you like to follow?	
6	S: Mining engineering	+1
7	I: Will you explain why mining engineering?	
8	S: Mining engineering is a very interesting field. In mining you deal with extraction of metals. The company which uses metals is the company that I want to work for … I'm interested with working with the elements of the Periodic Table.	
9	I: Is your interest in science declining, increasing or remaining the same as you move from the GET phase to the FET phase?	
10	S: It's increasing since I find it more interesting even though it's hard sometimes but I try to meet the standards of science.	+1
11	I: How do you compare your relationship with your science teachers in grade 7, 8 and 9 with your science teachers in grades 10, 11 and 12?	
12	S: Now the science teachers are a bit harsh about the work and in grade 7 grade 6, they were just teaching you everything, but now they tell you: the reason you are doing science is because you wanna be someone. So they teach you in such a way that you become interested more and more in science.	-1
13	I: Is the way science taught in the FET phase meeting your expectations?	
14	S: No it's not, because most of the time we only do theory and we don't normally use the labs, especially in chemistry for practical so you can understand more if you do practical but when you only do theory sometimes it's hard to understand	-1

No	STATEMENT	Code
15	I: In your own words, how would you describe the transition from the GET phase to the FET phase focusing attention on the transition from Natural Science to Physical Science.	
16	S :Natural Science was just basic things, something like general knowledge but now when you come to FET there are laws … Newton's Laws and everything. Before you do anything in science you have to understand the concepts first. So, it's hard yeah, it's hard.	-1
17	I: Now, let's get to the diagnostic test. In the first question you chose set 3. Please explain why you chose set 3.	
18	S: Because in set 3 they said they are equal atoms – and the question said: in which of the containers had one mole so if ever the container has equal … the atoms are equal … when they are about to bond … it means there was one mole, one mole one mole in each before the reaction	-1
19	I: Before which reaction?	
20	S: It's tin, magnesium and sulphur, so in each of the sets they are … ok, this one is one mole one mole one mole, if ever you are doing a reaction, let's say nitrogen and hydrogen then you use one mole one mole to give you the forward reaction	
21	I: Let's come to the second question. Explain why you chose green containers	
22	S: Sulphur has one mole but it has two atoms of oxygen, that's the main reason why I chose green containers	-1
23	I: Tell me, what do you understand by a mole?	
24	S: I think it's the number of atoms which are needed for a particular reaction to happen	0
25	I: Thank you	

Humphrey Edwards

No	STATEMENT	Code
1	I: What is your favourite subject in the FET phase	
2	S: Actually it's English	-1
3	I: Explain why English	
4	S: It's English because… actually I like novels … I like books much … we get to do books and in those books we get life skills … like for instance the book we are doing Maru – it takes you through a journey of somebody, then you get to learn such things.	
5	I: What career would you like to follow?	
6	S: Metallurgical science …in fact it's between metallurgical science and electrical science but I think I love metallurgy most.	+1
7	I: Is your interest in science declining, increasing or remaining the same as you move from the GET phase to the FET phase.	
8	S: I think it is increasing because from grade 10 to grade 12 we were introduced into new things like for instance momentum and the rates of reactions … you get to know how something happened that I did not understand how they occurred … but now through science I understand why is it that all things go down and not up … so I think being introduced to new things … things that are related to everyday life … I think it is increasing.	+1
9	I: How do you compare your relationship with your science teachers in grades 7, 8 and 9 with your science teachers in grades 10, 11 and 12?	
10	S: I think from grade 10 downwards, the relationship was kind of a parent and child .. because we were not .. they still took us as children .. . like they had to guide us … talk to us … understand us but since from grade 10 to grade 12 sometimes we were taught by an HOD … he's got a lot of duties so actually he just comes to teach you … you only have time to talk in class because they teach different classes and some are deputy principals they have to do some things … so it's kind of a distant relationship	-1
11	I: Is the way science taught at the FET phase meeting your expectations?	

No	STATEMENT	Code
12	S: Yeah I think so because in most cases you are taught something for instance you are taught Le Chaterlier's Principle and after you perform an experiment to prove whatever you have been told. In FET, no before, grade 7 downwards you were only taught something, volcano, combustion …. But now there are experiments you can perform to prove what you have been taught	+1
13	I: In your own words how do you describe the transition from the GET to the FET phase focusing on the transition from Natural Science to Physical Science	
14	S: I think the transition was big, because the way I understand it, Natural Science was the combination of Biology and Physics so in the FET phase like this they put them into two. In Physics we use formulas and everything and in Natural Science we deal with things like volcano … we focused more in the theoretical part. But now in the FET you have to know your theory together with your calculations and you get to be told new things that you didn't know, that you were not taught and some of the things are abandoned from grade 7 and in grade 10 you do new things.	-1
15	I: Now coming to the diagnostic test: explain why you chose set 1?	
16	S: I chose set 1 because … first of all we are just given the number of moles which is 1and we are not given the quantity of the volume so I decided to make the volume of each container to be 1, then I took the formula n = V/Vr Vr which is the S.T.P … I took the volume of each container to be equal to that of the S.T.P then I used the formula n = V/Vr which then I got 1… and because now the moles of tin, mole of magnesium and sulphur were each taken to be one … so then I did one calculation and concluded that all of them in set 1 must be 1 because I assumed that … the volume of each container must be equal to that of the S.T.P. That's the reason I chose set 1	0
17	I: What do you understand by a mole?	

No	STATEMENT	Code
18	S: A mole is …we calculate things in masses like for instance we've got kilograms, we've got grams and we've got milligrams but in science in most cases we experiment using smaller quantities … we take grams and convert it to molar … in a form of moles, so that it cannot be in that large number like kilograms	0
19	I: In the second question: explain why you chose green containers	
20	S: I chose the green container … I used the oxidation theorem … I used the valency numbers … I tried to find the oxidation number for oxygen in each container … then I found the oxidation number of SO_2 to be 2,5 and then again I found the … I found it to be 2,5 in both cases … then I said it is the green container because the number of moles in each container is the same … because the ratio of oxygen in each container is the same … so I concluded that the number of moles is the same both in the … due to the calculation that I have made.	-1
21	I: Have you ever heard of Avogadro's hypothesis?	
22	S: Avogadro's hypothesis? I think I've heard of … no, I think I just heard of it in passing … I've never like told in details	
23	I: Thank you	

Louisa Ericsson

No	STATEMENT	Code
1	I: What is your favourite subject in the FET phase?	
2	S: My favourite subject is Biology	-1
3	I: Will you explain why Biology?	
4	S: Biology is kind of interesting to me … I want to pursue a career that falls under Biology … which is gynaecology … because I'm more interested in knowing a woman's body; so, I do like Biology	-1
5	I: Ok. Is your interest in science declining, increasing or remaining the same as you move from the GET phase to the FET phase?	
6	S: It is declining, because in … what was the phase?	-1
7	I: The GET phase	
8	S: The GET phase … it was more simpler than this phase I'm in now. *I think it is also because what we did then is not the same as what we are presently doing because of the change in curriculum*	
9	I: How do you compare your relationship with your science teachers in grades 7,8 and 9 with your science teachers in grades 10, 11 and 12?	
10	S: *There is a difference … the teachers in grade 10 were different and are not the same as the teacher I have now … they have different teaching strategies*	0
11	I: Is the way science taught in the FET phase meeting your expectations?	
12	S: Yes, it does	+1
13	I: In your own words, how would you describe the transition from the GET to the FET phase focusing on the transition from Natural Science to Physical Science	
14	S: *In Natural Science things were much simpler. Right now we do many things that we did not do in Natural Science.*	-1
15	I: Ok. Let's now come to the diagnostic test. Explain why you chose set 1.	
16	S: *I chose set 1 because I realised that the molecules were equal so I thought that they had 1 molecule*	-1
17	I: What do you understand by a mole?	

No	STATEMENT	Code
18	S: A mole? I think … an element that can react with other element to form maybe.	-1
19	I: Tell me, why did you choose blue containers in the second question?	
20	S: Why I chose blue containers? Because both elements have a bigger number of mass … they contain less number of atoms … *I was using a Periodic Table when I answered this question … I found that one container had a gas and the other one consisted of a liquid. That's why*	-1
21	I: Have you ever heard of Avogadro's hypothesis	
22	S: NO	
23	I: Not at all?	
24	S: Not at all	
25	I: Have you ever heard of Avogadro's number?	
26	S: No	
27	I: Not at all?	
28	S: Not at all	
29	I: Thank you	

Lenah Edwards

No	STATEMENT	Code
1	I: What is your favourite subject in the FET phase?	
2	S: Life Orientation	-1
3	I: Explain why Life Orientation	
4	S: Because it is the most subject that I like	
5	I: Why , why like it?	
6	S: It deals with exercising and I like to exercise	
7	I: What career would you like to follow	
8	S: I would like to follow nursing	-1
9	I: Why would you like to follow nursing?	
10	S: I like to deal with health problems … I like to help sick people	
11	I: Is your interest in science declining, increasing or remaining the same?	
12	S: Decreasing … because I see that when I came from primary school to secondary school, the primary school and the high school is not the same; at high school it is the place where you have to work hard and know what you want in life	-1
13	I How do you compare your relationship with your science teachers in grade 7, 8 and 9 and your science teachers in grade 10, 11 and 12:	
14	S: I think they are the same, I don't see any difference	0
15	I: Is the way science taught in the FET phase meeting your expectations?	
16	S: I do not understand the question	
17	I: You are now doing Physical Science; you used to do Natural science in GET. In Physical Science .. is it the way you expect it to be taught	
18	S: No	-1
19	I: In your own words how would you describe movement from GET i.e. grade 9 downwards, to grade 10, 11, 12?	
20	S: In grade 9, 10, 11 is not the same as in grade 12 because in grade 12 … I think that is the grade that is the most difficult. And we have to work hard so that you can achieve your dreams or goals	-1
21	I: Ok. Let's come to the diagnostic test. In question 1 you chose set 2. Explain why you chose set 2.	

No	STATEMENT	Code
22	S: I was just thinking that in set 2 there was more concentration	-1
23	I: What do you understand by a mole?	
24	S: I think it's an element	-1
25	I: Ok. Let's get to the second question. Explain why you chose blue containers.	
26	S: I was thinking that I added the red container with the green container, they will remain the same as the blue colour container	-1
27	I: Have you ever heard of Avogadro's number?	
28	S: No	
29	I: Have you ever heard of Avogadro's hypothesis?	
30	S: No	
31	I: Ok. Thank you very much	

APPENDIX K

Examination content and weighting of LO's for grades 10 & 11 (DoE, 2005(c))

Weighting of the Learning Outcomes and specification of content across the two papers for the Grade 10 and 11 end-of-year examination (Department of Education, 2005)

		PAPER 1: PHYSICS FOCUS	**PAPER 2: CHEMISTRY FOCUS**
Duration		**3 hours**	**3 hours**
Maximum marks		**150 marks**	**150 marks**
Content		**Mechanics Waves, sound and light Electricity and magnetism Matter and materials Electronic properties of matter Atomic nuclei**	**Chemical change Chemical systems Matter and materials Atomic combinations: Molecular structure Ideal gases and thermal properties**
LEARNING OUTCOME		**WEIGHTING**	
Learning Outcome 1:	Practical scientific inquiry and problem-solving skills	30%	30%
Learning Outcome 2:	Constructing and applying scientific knowledge	40%	40%
Learning Outcome 3:	The nature of science and its relationship to technology, society and the environment	30%	30%

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

APPENDIX L

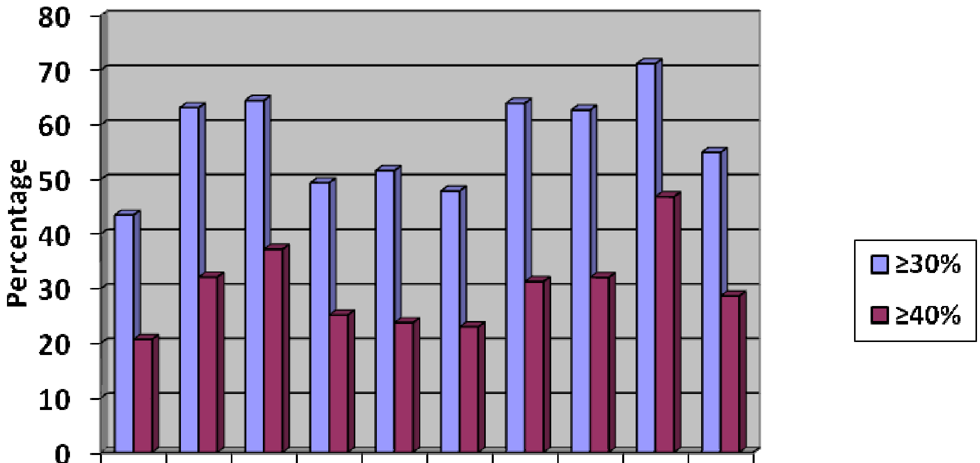
NATURAL SCIENCE: CORE KNOWLEDGE AND CONCEPTS – GRADE 9 NCS (Hand-out from GDE, 2006)

LIFE AND LIVING		
Life processes and healthy living	**Interaction in the environment**	**Biodiversity, change and continuity**
▪ **Human reproduction: What is reproduction** - **Fusion of sex cells** from mother and father, carrying the patterns for some characteristics of each - **Conception,** baby growth and development – growing and changing into adult - **Prevention of sexually** transmitted diseases including HIV/AIDS must be followed by behaviour choices ▪ Humans go through physical changes as they grow older**:** **Physical changes during puberty in boys and girls** ▪ **Excretion: Elimination of waste products** - Different organs that eliminate waste from the body: lungs, kidneys, skin and - The role of water in this process - Explain what is Homeostasis - **All living things depend on water passing through them in various ways, using structures such as kidneys, skin and stomata in plants** ▪ **Respiration: Breathing system** Oxygen which is provided by breathing system, reacts with food substances to release energy - Breathing organs - Cellular respiration ▪ **Circulatory system** - Parts of the circulatory system - What forms blood - Functions of the circulatory system – carries nutrients and oxygen to all parts of the body and remove waste products	▪ **Human reproduction** also involves adult raising children, which requires judgement and values and usually depends on the behaviour of other people in the community and environment	▪ **Conservation** **Causes of the loss of biodiversity: Human activities such as:** - Introduction of alien species - Habitat destruction - Population growth - Pollution **Extinction through natural events** ▪ **The cell** is the basics unit of most living things, and an organism can be formed from one or many cells. Cells themselves carry on life processes such as nutrition, respiration, excretion and reproduction, which sustain the life of an organism as a whole

<table>
<tr><th colspan="3">ENERGY AND CHANGE</th></tr>
<tr><th>Energy transfer and systems</th><th colspan="2">Energy and development in South Africa</th></tr>
<tr><td>▪ Electricity (Electrical energy)
Static electricity
Current electricity
- Charge
Electric current
Current convention, The coulomb, The use of the Ammeter, Potential difference, Resistance and how to measure, resistance, Factors which determine the resistance of metallic conductors, Series and parallel connectors of cells and resistors, Circuits and circuits diagrams, Household wiring and a model of a household wiring
▪ Cost of electricity
▪ Safety measures</td><td colspan="2">▪ Supply of electrical energy from power plants to households (discuss also energy supply and usage in rural areas, e. g usage of wood, etc)
▪ How electrical energy is generated</td></tr>
<tr><th colspan="3">PLANET EARTH AND BEYOND</th></tr>
<tr><th>Our place in space</th><th>Atmosphere and weather</th><th>The changing earth</th></tr>
<tr><td>▪ The sun is the major source of energy for phenomena on the earth's surface such as the water cycle</td><td>▪ Climate varies in different parts of the globe (emphasis should be on the adaptation of plants and animals to living in different climate regions). Link with Life and Living</td><td>▪ Mining and Minerals</td></tr>
<tr><th colspan="3">MATTER AND MATERIALS</th></tr>
<tr><th>Properties and uses of material</th><th colspan="2">Structure reaction and change material</th></tr>
<tr><td>▪ Matter
Properties of the different phases of matter in terms of
- Divisibility of matter
- Mixing and diffusion of gases and liquids
- Compressibility, crystalline structures
- Brownian Motion
- Forces between the particle</td><td colspan="2">▪ The particle model of the three phases of matter
▪ Chemical change of substances
- Atoms and molecules
Elements and compounds
Periodic table
Symbols and formulas
Chemical equations
- Combustion: What is combustion?
Combustion as reaction with oxygen: Investigate the combustion of Hydrogen; Carbon, Sulphur, Magnesium and Iron in Oxygen. Represent the reactions with chemical equations.
- Heating of substances
Decomposition of substances by heating. Investigate the heating of copper carbonate, mercury oxide and ammonium carbonate. Show chemical equation to represent the reactions
▪ Reaction of Acids with:
- Metals, Oxides, Carbonates, Alkali (Bases)</td></tr>
</table>

APPENDIX M

2008 Grade 12 Physical Science results per province (DoE, 2009),



	EC	FS	GP	KZN	LP	MP	NW	NC	WC	NAT
≥30%	43.	63.	64.	49.	51.	47.	63.	62.	71.	54.
≥40%	20.	32.	37.	25.	23.	23	31.	32.	46.	28.

APPENDIX N

The composition and pass requirements of the National Senior Certificate (DoE, 2009).

NATIONAL SENIOR CERTIFICATE (NSC)

Three-year programme (Grades 10 – 12)

All candidates must offer seven subjects:

- ✓ Two Languages (Home Language Compulsory);
- ✓ Math/Math Literacy;
- ✓ Life Orientation and;
- ✓ Three choice subjects

The National Senior Certificate requires minimum of three subjects achieved (passed) at 40% and three subjects at 30%.

25% of mark is school-based assessment and 75% from external examination.

APPENDIX O

CLASS OF 2008 (DoE, 2009)

- ✓ In Grades 3 – 9 offered Curriculum 2005 and in Grades 10 – 12 (2006 to 2008) NCS
- ✓ Record number of learners: 150 000 more than in 2003 and 28 000 more than in 2007
- ✓ No repeaters or part-time learners
- ✓ More female than male candidates

Categories of achievements	Number of candidates	Percentage	Achievement requirements
Achieved – Bachelors (University admission)	107 462	20.2%	NSC and a minimum of 30% in the LOLT of the higher education institution coupled with an achievement rating of 4 (50-59%) or better in four subjects from the designated list
Achieved – Diploma (Admissions for Technikon)	124 395	23.3%	NSC and a minimum of 30% in the LOLT of the higher education institution coupled with an achievement rating of 3 (40-49%) or better in four recognised NSC subjects
Achieved - Higher Certificate (Ordinary pass)	102310	19.2%	NSC and a minimum of 30% in the *LOLT of the higher education institution
Did not achieve	60 000	11.25%	
Number qualified for supplementary	142000	26%	
Total	533 561		

*LOLT – Language of learning and teaching