AN ANALYSIS OF GRADE 9 LEARNERS' PERFORMANCE IN THE 2004 NATURAL SCIENCE COMMON TASKS FOR ASSESSMENT WITH SPECIAL REFERENCE TO SCIENCE PROCESS SKILLS, LEARNING OUTCOMES AND ASSESSMENT STANDARDS

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by

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DECLARATION

I declare that *An analysis of Grade 9 learners' performance in the 2004 Natural Science Common Tasks for Assessment with special reference to science process skills, assessment standards and learning outcomes* is my own work, that it has not been submitted before for any degree or examination at any other university, and that all sources I have used or quoted have been indicated and acknowledged as complete references.

Signed: . Signed by candidate

Ferial Mullajee

November 2008

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"What we have done for ourselves alone dies with us; what we have done for others ...remains and is immortal." ~ Albert Pike

"One looks back with appreciation to the brilliant teachers, but with gratitude to those who touched our human feelings". ~ Carl Jung

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ABSTRACT

In 2004 an educational evaluation strategy consisting of Common Tasks for Assessment (CTAs) was introduced nationally into South African high schools as an external examination, marked internally by individual teachers. It took the form of a systemic assessment for Grade 9 learners with the main intentions of promoting a common standard and serving as a validating tool for school-based assessment. This analytical-descriptive investigation in 12 schools (in the Western Cape is a contribution to the research fields of academic performance testing, achievement and response.

CTAs use the framework of the curriculum, broadly defined as the organising principle in how educational opportunities are provided to learners. Hence, the basis of the CTA model has three aspects: the intended curriculum, the implemented curriculum, and the attained and experienced curriculum.

The CTA testing took place in 2004 with many schools participating.

The CTA assessment in the area of Natural Science was framed by two organising dimensions: a content domain and a cognitive domain. The content domains that framed the science curriculum were presented as themes: *life and living; energy* and *change and matter and materials.* The cognitive domains were: *factual knowledge, conceptual knowledge*, and *reasoning and analysis.*

Research design and methodology

The focus of the study was on investigating the responses of conveniently available diverse classes of learners to the 2004 national Grade 9 CTA Natural Science test paper that was two hours long.

The key research questions were:

1. How did a sample of 1500 learners and their teachers experience the 2004 Grade 9 Natural Science Common Tasks for Assessment (CTA) as an instrument of performance and educational achievement?

2. Why did the learners perform in the ways that they did, and what deeper insights into the learners' achievements on the CTA were gained when their responses were analyzed?

An exploratory *ex post facto* research design was adopted during Phase 1 of the study which comprised the **feasibility study** in these schools. In Phase 2, a quantitative approach was engaged in an expanded status study using 12 schools. In Phase 3, a qualitative methodology was utilized with purposefully selected samples of learners and teachers when data gathered through interviews were subsequently **analyzed** in terms of theoretical **explanatory** factors and variables that may have influenced their performance. The purpose of the status study was to utilise an *ex post facto* research methodology. It described the arrangements made for the large-scale collection of quantitative data once again. The selection, size, context and nature of the twelve high schools were described. Next, the data collection procedures for Phase II were described in terms of their ethics, management, permission, sequence and time-table. Then the lists of dependent and independent variables were presented and finally, the intended data, processing procedures and techniques were introduced.

The interviews with teachers had two main purposes. These were to assess the perceived quality of the test using professional and academic criteria such as those suggested by Ebel (1972) and RNCS (2002); and also to obtain recommendations for improving the format and content of future CTAs in the Natural Sciences.

For the quantitative study the sampling design used a stratified cluster design, which involved selecting samples of schools from all eligible schools on the basis of definitions of levels of socio-economic status.

For the qualitative studies, the interviews with learners and teachers were chosen purposefully. The interviewed teachers were chosen based on the school's overall performance in the CTA and the teacher's experience in teaching Grade 9 Natural Science. Six teachers were interviewed during a five day period in September 2005, selected from various schools with different levels of SES. The learners were divided (on paper) according to low, medium and high achievers, i.e. the teacher chose two or three learners from each group who expressed willingness to be interviewed in either English or Afrikaans. Learners were chosen in this way in order to get a good spread of achievement levels.

Findings

Natural Science performance in 12 Western Cape schools.

1. Overall performance by the 12 schools on the 2004 Science CTA

   The overall mean score for the 1 572 learners on the Science CTA was a low 38.3% ± 29.9%. The variation in scores on the CTA ranged from many very low to a few very high scores, meaning the score distribution was skewed to the left.

2. Performance patterns in the scores generated by the Grade 9 CTA in Science.

2.1 Analysis of the CTA achievement scores by SES

   The top performing schools for CTA science were those with the highest levels of SES. There was a distinct pattern in achievement levels from the highest SES to the lowest SES in the order: highest SES (mean score 57%) > medium SES (mean score 49%) > normal SES(mean score 41%) > lowest SES (mean score 15%).

2.2 Analysis of CTA scores by gender

   There was a highly significant difference between the performances of males and females in the total score of the Science CTA, where females (mean score 41.4%) performed better than males (mean score 33.8%). There were also highly significant performance differences between males and females in 20 out of the 25

CTA items, in which the females attained the better mean scores. Highly significant differences between males from an all boy's school and females from an all girl's school appeared among only the highest level of SES schools.

2.3 By school

The average achievement scores in the Science CTA of the schools showed great variation. The top performing schools were the ex-Model C schools. The top performing schools (57%) recorded mean scores were almost double those of the lowest performing schools (15%).

2.4 By schools categorised by ex-racial department

There were differences in the average CTA achievement scores of learners in schools categorised by their former racial departments. The mean scores of the learners in the former House of Representative (HOR) and former Department of Education and Training (DET) schools was almost half that of learners in the former House of Assembly (HOA) schools. An analysis of the achievement scores in the different school types (categorised by ex-racial department) indicated that the attendance of learners at different school types may have been an important determinant in influencing learner achievement outcomes.

2.5 By language of the test

Learners answered the CTA test in either Afrikaans or English. In the majority of test items, English learners performed better than Xhosa and Afrikaans learners. English second language participants at higher level SES schools achieved significantly higher scores than those English second language participants who attended lower level SES schools. The English second language participants from the highest SES schools achieved slightly higher scores compared to the English first language participants from lower SES schools but achieved a significantly higher score compared to English first language participants from the lowest SES schools. There was a notable relationship between learners' lower achievement in the CTA and the fact that they did not speak the language of the test at home.

2.6 By what learners know and can do

The 1572 Western Cape learners performed relatively poorly on almost all test items (>50% of the items) on the CTA. The items in which most learners greatly under-performed were based on the process skills: 'identifying variables' and 'interpreting graphs'.

3. The CTA instrument itself

A detailed analysis of the scripts of individual learners revealed several aspects in the management, wording and structure of the CTA examination paper itself that appeared to impact on the low performance of learners. Follow-up interviews with the learners and teachers disclosed shortcomings in the CTA that included incorrect allocation of time; ambiguity in the wording of particular items; language inaccuracies; and so on.

4. Curriculum

The CTA test instruments were administered during a period of curriculum change and restructuring. The philosophy underpinning the restructured curriculum was that of an outcomes-based education. The official curriculum in 2004 was C2005, and this was characterized at the time by an under-specification of basic knowledge and skills in all learning areas, including science. This study analysed information from a large-scale paper-and-pencil test and found several mismatches between the intended curriculum, the implemented curriculum, and the curriculum experienced by learners and their teachers, especially with regard to clarity of content and skills taught, classroom teaching and skills tested and an unrealistic time limit.

5. Class size for the 12 schools

The class size varied according to the SES of the school. In the highest level SES schools the average class size was 25-30 learners. In the second and third level SES schools the average class size was 35-40 learners. In the lowest level SES schools the class size was 40-50.

6. Participation in national systemic studies
   It may be important for all South African learners to participate in a national systemic assessment which externally benchmarks performance.

It is anticipated that the findings of this investigation may be of some value to future learners, teachers, curriculum planners and CTA examiners. This study engaged in identifying and selecting certain CTA-related aspects in the teaching and learning of science such as misconceptions, lack of skills, misinterpretations and inadequate 'prior knowledge' that might hamper further understanding in higher grades. The findings emanating from this study may be valuable in that they could inform science teachers of the common problems that learners encountered. Because the learners participating in this study were found to hold inadequate and widespread notions of certain concepts in science, it seems probable that many present and future Grade 9 learners might also hold similar misconceptions. The findings of the study might also prove to be informative and useful to science teachers in the design of their future lessons and instructional practices. In other words, by identifying and documenting the problems that learners appear to have experienced during the past few years (with some of these local findings linking to those of other previous studies), cognisance may be taken of these specific aspects of learning to try to alleviate the inconsistencies where they appear to prevail among the schools.

It is anticipated that this study will also be of benefit to curriculum planners and CTA examiners by imparting information derived from an intensive analysis of learners' responses to questions - with regard to noting test designers' possible shortcomings in layout; degree of abstraction; ambiguity; appropriateness for RCNS; diagrammatic representation; and the validity of the test items examined.

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LIST OF ABBREVIATIONS

ABET	Adult Basic education and Training
AIDS	Acquired Immuno Deficiency Syndrome
ANC	African National Congress
AS	Assessment Standards
CASS	Continuous Assessment
C2005	Curriculum 2005
CO	Critical Outcome
CTA	Common Task for Assessment
DET	Department of Education and Training
DC	Direct Current
DoE	Department of Education
DO	Developmental Outcome
FET	Further education and Training
GET	General Education and Training
GETC	General Education and Training Certificate
GRD	General Regulative Discourse
HOA	House of Assembly
HOD	House of Delegates
HOR	House of Representatives
ID	Instructional Discourse
LO1	Learning Outcome 1
LO2	Learning Outcome 2
LO3	Learning Outcome 3
Model C	Model C schools
NCS	National Curriculum Statement
NGO	Non-governmental Organization
NQF	National Qualifications Framework
NS	Natural Science
R-9	Pre-primary to Grade 9
RD	Regulative Discourses

RNCS	Revised National Curriculum Statement
RPL	Recognition of Prior Learning
SAQA	South African Qualifications Authority
SES	Socio-economic Status
SID	Specific Instructional Discourses
SKAV	Skills, Knowledge, Attitudes and Values
SRD	Specific Regulative Discourses
TIMSS	Third International Mathematics and Science Survey
TIMSS-R	Third International Mathematics and Science Survey-R
WCED	Western Cape Education Department

CHAPTER 1

INTRODUCTION

1.1 Prologue

The intention of this study is to analyse and explain - both quantitatively and qualitatively – both the performance and some of the experiences of 1572 Grade 9 learners from 12 high schools in the Western Cape on the 2004 Natural Science Common Tasks for Assessment (CTA) examination. It also seeks to identify and gain insights into some of the tensions and explanatory factors that may have influenced the learners' performances, with particular reference to issues involving science process skills, the contexts of assessment formats, language of testing, gender, socio-economic status and curriculum-specified learning outcomes. In this study selected learners and teachers were interviewed on their perceptions and experiences of the implementation of the Natural Science CTA examination at various schools to try to establish why they were achieving or under-achieving. This investigation uses one particular instrument – a CTA in the Natural Sciences – as a potential tool to analyse performance. It also analyses both strengths and shortcomings in the original wording and composition of the 25 test items which comprised section B of the CTA, in its implementation in 2004. However, the dissertation is not a critique of CTAs, in general, as a form of assessment.

The study is set in the context of current theories of learning, continuous assessment and common tasks for assessment. The study as a whole endeavours to make a contribution to the field of educational performance testing in high school science by enhancing our understanding of the diverse South African context in which testing takes place.

This chapter describes the statement of the research problem, its background, context, purpose and significance of the research. It identifies the assumptions of the study and its limitations. The chapter introduces and justifies the selection of the research design and methodology; it describes the data-generating phases and procedures; and it indicates the techniques selected for processing, treatment and analysis of the data.

1.2 Statement and origin of the problem

For decades one of the purposes of science education research has been a striving for quality in the various aspects of science teaching, learning and assessment. Hence, in the present study I, the researcher, have attempted to investigate in depth the performance of a diverse group of Western Cape learners in the 2004 Natural Science CTA, Section B (attached in Appendix 1). I will also evaluate its pedagogical worthiness (its strengths and weaknesses) as an aid to classroom assessment. I was motivated by the self-reported experiences, concerns, fears and complaints expressed by colleagues, and by my curiosity as to whether these are justified.

The educational value of the CTA as a potential aid to learning has been under scrutiny, especially during the past four years. In particular, concerns about the proficiency of its implementation with regard to possibly inadequate administrative planning and alleged lack of consideration for teachers and learners have been emphasized. For example, the following are some of the comments that were printed as SMSs to the Cape Argus (2005:18):-

> Not only do our Grade 9s have to struggle to finish the CTA in two weeks but the conditions under which they have to work are less than ideal. Up to 45 students in prefabs which are extremely hot. Both students and teachers are stressed and can't wait for this nightmare to end. (Teacher)

> I'm a Grade 9 learner…We had 10 periods each day last week in which we had to complete our CTA (which came late) and started exams yesterday. We also got homework every day. It really is frustrating and stressful. (Learner)

According to Education Department Director for the North Metropole, Barry Volschenk, schools would be ordered to conduct the programme of CTAs, in spite of the confusion at the time, because this was a compulsory national requirement (Bailey & Smith, 2005). This was echoed by the Deputy Director-General for Education Planning and Development in the Cape Province, Brian Schreuder, who said, "Final exams (*sic)* were not compulsory, but CTAs were essential for assessment" (Bailey & Smith, 2005:3).

According to Wilmot (2004), curriculum and assessment decisions have often been influenced by political decisions. In Britain, for example, the Thatcher government passed the Education Reform Act of 1988 because of a decline in education standards. The Act included both a national curriculum and a national testing system (Tell, 1998). One of the main purposes of national assessment was to "make sure that teachers teach the national curriculum" (Gipps & Stobart, 1997:14). British national testing resembled the current systemic evaluations being conducted in South Africa at ages 7, 11 and 14 years to monitor standards.

Time was a major factor in the process. In Britain, external markers were employed to mark test papers, test papers were returned to schools and teachers were allowed to question any inappropriate marking (Tell, 1998). However, in 2004 South African teachers were under pressure to mark the CTAs and there was no time for formative assessment. According to Tell (1998), the British tests were fairly valid in that they genuinely sampled the curriculum. As occurred in Britain, assessment in South Africa is now being used as a valid tool for monitoring and judging standards. This is evident in the national testing of the CTAs.

In South Africa, the Assessment Policy for General Education and Training of the Department of Education (DoE, 1998a) made provision for widespread systemic evaluation, to be conducted at the Grades 3, 6 and 9 levels "on a nationally representative sample of learners and learning sites in order to evaluate all aspects of the school system and learning programmes" (DoE, 2002a:2). This was the same process as in the United Kingdom (Gipps & Stobart, 1997). The three objectives of the systemic evaluation of the CTAs (on which this study was based) were to: obtain information on learner achievement; identify factors that affect learner achievement and make conclusions about appropriate education interventions (DoE, 2002a:3). To date no comprehensive analysis has been conducted on the implementation of the Grade 9 Natural Science CTA in the Western Cape, which concentrated on the application of new skills specified in the new curriculum and the performance of different categorized schools.

1.3 The 2004 Natural Science CTA examination

In South Africa, Common Tasks for Assesment (CTAs) - which can be regarded as constituting forms of standardised testing, i.e. systemic assessments - were intended to be set externally and marked internally. One could view CTA testing as reflected in this quotation:

> Standardised tests were never intended to be the key component of student evaluation. They were intended to be a valuable ingredient that would combine with many other assessments to create a more accurate picture of a student's educational profile.
> (Burke, 1997, cited in the Department of Education and Training: Government of Western Australia, 2000)

According to a document, *A draft framework for the development of the CTAs* (DoE, 2002b:10), the Department of Education stated that the CTA should be designed as series of performance-based assessment tasks, which "emphasises the learners' ability to use or transfer their knowledge, understanding and skills into action" in a real life situation. These real life context problems are composed of two parts of information provided to the learner. The first part describes the context in the form of a story and the second part provides the learner with the information required to answer the questions (see Appendix 1). Section B should assess individual learners' performance, using a paper and pencil test. These tests could be designed by "using objective and or free response questions" (DoE, 2002b:16). Free response items assess higher analytical skills, i.e. problem solving, decision making, drawing inferences and hypothesising.

Bansilal (2008) argued that mathematically contextualized tasks – and by inference in this study, scientific tasks - could also be classified as literacy tasks. These performance-based assessment tasks could also be used in a systemic way to evaluate reasoning skills and outcomes.

CTAs can be used on a small scale (for example in two schools) or on a very wide scale (e.g. throughout the whole country), for one or more learning areas and for any grade. Although the initial purpose for the South African CTA was to enable school leavers to qualify for and obtain a GETC (General Education and Training Certificate), it can also provide an opportunity for teachers and learners to compare their progress and status with that of learners in other schools. Also, it can be used to assess learners, evaluate teachers, "set a standard for teachers" and "highlight areas in the curriculum that need attention" (Siebörger, 2004:79). Today this purpose may seem unfair to teachers since it places pressure on teachers to achieve results instead of improving the quality of learning (Siebörger, 2004).

The intended purposes of CTAs were to:

- ensure consistency in teacher judgements;
- promote common standard setting;
- strengthen the capacity for school-based continuous assessment;
- increase the accuracy of the assessment process and tools;
- ensure that the school-based assessment tasks properly assess competencies and achievements; and
- ensure expanded opportunities for learners.
  (DoE, 2002c:79)

In practice, a CTA - comprising sections A and B - could have been used both **formatively and summatively** in 2004. Section A could have been used formatively if learners had been given back their attempted tasks to check them to see where they went wrong and where and how they could have improved, i.e. "to grow and to make progress" (Siebörger, 2004:22). Furthermore, it could have been used in a summative way (Section B) "to demonstrate that an outcome or assessment criterion had been attained" (Siebörger, 2004:37). Nevertheless, in 2005 and 2006 only Section A was issued to schools. However, in 2007, both Section A and Section B were issued to schools.

1.4 Assessment for the General Education and Training Certificate (GETC) and its purposes

The South African Interim Policy Framework for the Assessment and Promotion of Learners in Grade 9 (DoE, 2003a) outlined the assessment and promotion requirements applicable to Grade 9 learners in the schooling system. It stated that the General Education and Training (GET) Band, Grade 9, demarcates the end of the compulsory phase of schooling. Education in this band aims at providing learners with the basic competences or a broad foundation of knowledge, skills, values and attitudes needed for lifelong learning. Therefore it was envisaged that a General Education and Training Certificate (GETC), as prescribed by the South African Qualifications Authority (SAQA), should be offered in future.

In the case of schooling, the attainment of a GETC will provide accreditation within the National Qualifications Framework (NQF) and will also assist in the selection and placement of learners for further learning; it will have a filtering purpose and recognize competencies that learners have acquired during the ten years of compulsory schooling, including Grade R. The assessment requirements at Grade 9 level have been determined within the parameters of recent policies, i.e. Curriculum 2005 (DoE, 1997), the Assessment Policy for Grades R-9 (DoE, 1998b), the White Paper on Education and Training (DoE, 1995a), the Education White Paper 6 (DoE. 2001a) and the General Education and Training Certificate Policy (South African Qualifications Authority (SAQA), (DoE, 2001b).

The South African General Education and Training Certificate document (DoE, 2000:13) has given four broad purposes for a GETC which are:

- Political: for informed participation in a democracy;
- Social: for active involvement in community contexts;
- Personal: for empowerment, self-confidence and links with cultural capital; and
- Economic: for economic growth, in terms of providing a foundation for the acquisition of knowledge and skills needed for the world of work.
  (DoE, 2000:13)

A statement of purpose for the GETC was formulated as follows:

> The primary purpose of the GETC is to equip learners with the knowledge, skills and values that will enable meaningful learning participation in society as well as continuing learning in further education and training, and provide a firm foundation for the assumption of a productive and responsible role in the workplace
> (DoE, 2000:14).

The above purposes provide an indication of the GETC and its connection to the CTAs as an external examination in schools. Besides the fact that initially the CTAs were intended to be used for learners to obtain a GETC, they were also used as instruments to ensure that certain skills were taught to learners by the end of Grade 9 and to promote a common standard as stated above. The present study concentrates on how learners performed in the science process skills tested in the CTAs which are emphasized in the purposes of the GETC (DoE, 2000).

1.5 Issues in performance testing, outcomes and continuous assessment

1.5.1 Theoretical framework

This study is set in the context of constructivism, a theory about knowledge and learning. A behaviorist approach to learning proposes that when a learner learns to repeat an action this would improve his or her performance. In other words a behaviorist approach is based only on 'recall', which was traditional rote learning. Consequently this learning theory focused on learners' performances instead of the reasons that made them respond in a particular way (von Glasersfeld, 1995). Contrary to this latter form of learning, a constructivist approach has favored a response to new forms of learning in which learners are encouraged to analyse and interpret new information (Black, 1999). It is based on the belief that the reception of new knowledge is dependent on learners' existing knowledge and that formative assessment must strengthen this knowledge. Constructivism takes into account learners' preconceptions of a particular topic which could develop into misconceptions. For example, these misconceptions can develop from previous science lessons. The CTAs can be used to identify any form of misconceptions, whether or not they relate to previous research. This study takes into account the possibility of a lack of prior knowledge as well; i.e. learners could possibly not have been taught properly or they did not know the correct answers.

In the light of this theory, I have used the content and nature of the curriculum to analyse the content and nature of the CTA which has been used as a tool to drive educational reform. Thus it is necessary to look at the **intended** curriculum which includes the stated objectives of the curriculum pertaining to science; the **implemented** curriculum which refers to the instructional process implemented – in this case the CTA; the **perceived** curriculum as experienced by the learners and teachers; and the **achieved** curriculum which produced the learning outcomes and the outputs of the learners (Mills & Treagust, 2002, cited in Bansilal, 2008; Reddy, 2006a).

1.5.2 Issues in the classroom assessment of science

An examination of the literature on educational measurement and evaluation reveals that the notion of assessment is tentative and has been continuously changing globally (Black, 1998; Davis, 1998; Gipps & Stobart, 1997; Wilmot, 2003; Shepard, 2000). With the result, assessment has been the main instrument for transformation in education (e.g. Barnes, Clarke & Stephens, 2000; Davis, 1998).

The present study also analyses the performances of learners as part of the process of educational transformation - a result of this within the South African context. It investigates whether evidence of transformation is present in the CTAs. Transformational change has resulted in a new form of practice that includes the "notions of skill, re-skilling, transferability, competence, outcomes and life-long learning" (Edwards & Usher, 1994, cited in Wilmot, 2003:314). All the above notions fall under the umbrella of Outcomes-based Education (OBE) which forms the foundation of the South African curriculum. OBE proposes learner-centeredness which is the opposite of the didactic approach to teaching. It "strives to enable all learners to achieve their maximum ability" through a realization of the learning outcomes (DoE, 2002c:1).

OBE is based on Spady's four principles which are: "clarity of focus", "designing down", "high expectations" and "expanded opportunity for learners" (Spady, 1994:10). Since the present study deals with one form of assessment, the CTA, a brief discussion of how these principles of OBE are related to assessment may be important to understand. Vandeyar and Killen (2003) explained how the above principles related to assessment as follows:

- Clarity of focus - requires assessment to be clear so that proper inferences can be made about learners.
- Designing down - requires assessment tasks to provide information on how learners progress and their ability to move to the next level of competence.
- High expectations - require assessment tasks which are also challenging to learners. Thus learners will be provided with the opportunity to attain high levels of achievement.
- Expanded opportunity - advocates that all learners should be given enough time to complete a task and that more opportunities should be given to learners before a final assessment of their progress has been made.

Any form of assessment endeavours to measure the extent to which an outcome has been achieved. However, the assessment of outcomes is not without problems. Many other countries have experienced problems regarding the attainment of outcomes. According to Siebörger (2004) problems encountered in the other countries include: an increase in the workload for teachers; different interpretations by various teachers on different learning outcomes; difficulty in reaching consensus in the attainment of a Learning Outcome (LO) or Assessment Standard (AS); assumptions that traditional

examinations and tests have been stopped and that content has been replaced by skills and abilities.
However these problems could be solved by a number of strategies. Solutions to the problems, based on other countries' experiences have been provided by Siebörger (2004) as follows. Firstly, the workload could decrease if learners are taught to assess themselves; and also if more textbooks and other teaching resources are made available. Secondly, collegiality may offer a solution to interpreting assessment standards, outcomes and knowledge of whether an assessment standard (AS) or a learning outcome (LO) has been reached or not. This can be achieved if teachers meet regularly to discuss these concerns related to interpretation by reaching consensus, and to allow flexibility in the assessment of outcomes. Thirdly, traditional types of tests and examinations should continue as long as they are not the only form of assessment; and they should be designed within the context of OBE. Lastly, skills cannot be divorced from content. Even though the emphasis on content has shifted, it remains very important and should be taught properly. The CTA is a typical example of how skills and content are integrated; and an analysis of the performances of learners (in this present study) on certain sections of the work may determine whether or not this is true. It will also attempt to find out whether teachers are comfortable with the new approach to assessment.

Although, the system of OBE has been borrowed mainly from Australia, one should bear in mind that the contexts of the two countries are very different (Malcolm, 2001). Firstly classes in Australia, are smaller (25-28 learners) compared to South Africa (35-50 learners). Most schools in Australia can be considered to be more or less in line with South Africa's former Model C schools, which can be regarded as relatively 'advantaged schools' (see page 27). Australian schools are well resourced – unlike most South African schools. Although both countries are multicultural, in Australia the majority of learners speak English at home (Malcolm, 2001). In South Africa, it has been reported that some Xhosa learners who attended multicultural schools spoke English both at home and at school, but that the majority of learners were disadvantaged by the dominant language, English (Mda, 2004).

The main purposes of assessment, as stated in the Revised National Curriculum Statement (RNCS) (DoE, 2002c:77), would be: "to enhance individual growth and development; to monitor the progress of learners; and to facilitate their learning". The kinds of assessment that the present study will mainly allude to are: formative assessment, summative assessment and systemic assessment. According to the RNCS (DoE, 2002c:77), formative assessment "monitors and supports the process of learning and teaching" and "feedback is given to enable learners to grow". Summative assessment provides "an overall picture of learners' progress at a given time". Systemic assessment "is a way of monitoring the education system" and "is conducted at the end of each phase of the General Education and Training Band".

In the past, summative assessment was the form of assessment that seemed to have dominated assessment in education. Levels of achievement were measured only by examinations and tests. The recognition of a more potentially positive role for classroom assessment in supporting learning and motivation has now created a school-based formative assessment model that involves an increased role for teachers. Although it could be argued that formative assessment has always been used as a form of giving feedback to learners, it has most definitely not been widely used as a formalised continuous process where learners' progress is regularly or continuously monitored. According to Black (1998); Davis (1998); Gipps & Stobart, (1997) and Shephard, (2000) a new form of continuous assessment in school classrooms have been developed which gave all learners an opportunity to be assessed in many different ways.

On-going, formal systemic assessment has only been performed with Grade twelve learners in the past few years. Lately, in 2004, the CTAs were written nationally and, in 2007, Grade 11 learners were also given an external examination. The CTA differed slightly in its approach to the Grade 11 examinations in that it aimed to test mainly skills. It consisted of Section A, which targeted outcomes that were not best assessed in a 'pencil and paper exercise', i.e it emphasized performance-based assessment. This section was to be taught to the learners and completed by the learners before giving them Section B. It assessed the individual competence and focused on selected specific outcomes and skills (DoE, 2002b). The content and context was derived from section A, which meant that section A had to be covered well before being tested in section B. One of the common purposes for all these examinations was to monitor standards.

According to Reddy (2006a), systemic forms of assessment - which can also be referred to as achievement tests - have been conducted since the 1960s as a means of increasing government's accountability to improve the quality and performance of learners within the educational domain. However, these accountability tests have been criticised for their negative effects on teaching and learning, as believed by Shepard (2000:9), who stated that accountability tests "prevent and drive out thoughtful classroom practices". He argued that test scores are likely to increase without a corresponding improvement in student learning. These criticisms were supported by those of Whitford and Jones (2000) who also believed that accountability tests would inevitably lead teachers to pressurising the state into being more specific with the content to be tested. According to Whitford and Jones (2000) some believed that these standardised tests were good while others believed that teachers' professionalism was being reduced - since they were being obliged to teach what others had designed, without taking into consideration their individual learners. According to (Whitford & Jones, 2000), this would have a bad effect on teaching. This could also possibly result in teachers - being held accountable – to leave for schools with higher scoring learners. This view is supported by (Shepard, 2000).

1.6 The South African background and context of the research

1.6.1 The introduction of recent versions of the curriculum and curriculum policies

The South African Draft Assessment Policy in the General Education and Training Phase, Grades R to 9, and Adult Basic Education and Training (ABET) (Department of Education, DoE, 1998a) discussed and described assessment as performing a prominent role in educational reform and transformational education. Assessment procedures in the apartheid era resulted in a documentation of the negative effects of many types of examinations and testing. For example, the use of the Senior Certificate Examination as a requirement for university entrance and the provision for school leavers with a certificate resulted in a complicated system of subject classification of Higher, Standard and Lower Grade examination papers.

With the introduction of the new curriculum in 1998, an opportunity arose for South Africans to transform their assessment procedures from a "judgemental" to a "developmental" form of assessment (DoE, 1998a:16). The document described the inefficiencies with past assessment practices as follows:

- an increase in the failure rate due to promotion requirements, which in turn resulted in an increase in the drop-out rate of learners;
- need for teachers relying on written tests and end-of-year examinations;
- teacher-driven and traditional teaching and learning strategies;
- high failure rate in the Senior Certificate examination;
- examination marks were taken as the total assessment in certain subjects for learners;
- varied interpretations of continuous assessment that proved to be problematic;
- a high rate of unemployment for school leavers;
- lack of necessary skills from school leavers;
- lack of opportunity for learners with special educational needs; and
- the lack of accountability with regard to learner requirements.

These problems of the past have initiated an alternative form of continuous assessment. This new type of continuous assessment allows testing throughout the year. It involves work with many tasks and tests, and not just testing at the end of the year. It is a structured process of collecting information about the performances of learners measured against the Assessment Standards of the Learning Outcomes. This information on learners' work is usually kept in a portfolio. However, besides this type of continuous classroom assessment, the CTAs have been introduced as a form of external national test – so that learners can be assessed in a number of different ways instead of in the past, where only written tests and end-of-year examinations were considered. Also, the issue of accountability arose from the previous educational system. Being a national standardized test, a CTA can be used as a tool to compare how different schools are performing and, possibly, how schools could be held accountable. It can also be used to implement recommended skills stipulated in the RNCS (DoE, 2003b:20). The present study aims to enlighten and inform policy makers and teachers about the shortcomings or advantages of the new transformational strategies now being used by the Department of Education.

The South African Draft Assessment Policy in the General Education and Training Phase Grades R to 9 and ABET (DoE, 1998a:22) outlined that effective and informative assessment should:

- Have clear, direct links with the CO and LOs.
- Be integral to teaching and learning.
- Be balanced, comprehensive and varied.
- Be valid and fair.
- Engage the learners.
- Value the education and practitioner judgement.
- Be time efficient and manageable.
- Recognise individual achievements and progress.
- Involve a whole school approach.
- Involve parents actively.
- Convey meaningful and useful information.
- Cater for learners with special educational needs.
- Be bias free and sensitive to the gender, race and cultural backgrounds and abilities of learners.
- Improve the quality of learning.
  (DoE, 1998a:22)

A more recent Revised National Curriculum Statement Grades R-9 outlined the characteristics of assessing Natural Science as follows. It should be: "transparent and clearly focused"; "integrated with teaching and learning"; "based on predetermined criteria or standards"; "varied in terms of methods and contexts"; and "valid, reliable, fair, learner-paced and flexible enough to allow for expanded opportunities" (DoE, 2002c:77).

Since one of the dimensions of the present study has focused on performance of learners and the factors that might have influenced the learners' performance, it is necessary to understand the effect of the past on the educational system. A brief outline of the historical background of South African educational policy is described below.

Prior to 1994, the National Party government elected in 1948 implemented the apartheid education laws and the Bantu Education act of 1953. It managed to segregate government schools racially for more than four decades (Jansen, 2001). The apartheid government provided separate, racially divided but inequitable education systems: the Department of Education and Training (DET) for "Blacks", the Department of Education and Culture containing the House of Representatives (HOR) for "Coloureds", the House of Delegates (HOD) for "Indians" and the House of Assembly (HOA) for "Whites". These were funded unequally with DET schools being the most adversely affected in terms of funding. According to the Draft White Paper on Education and Training of South Africa's national Department of Education (DoE, 1994):

> ....the funding of education and training has been grossly unequal across the racial and ethnic subsystems. A century or more of discriminatory provision entrenched huge disparities in physical facilities, professional services and teaching quality. (South Africa, DoE, Government Gazette 1994:9)

After apartheid, in the mid-90s policy-makers were faced with a huge challenge to develop a new education system to serve the needs of the new democracy. This meant that public and private resources had to be used wisely to serve all learners under one education system (Fiske & Ladd, 2004).

However, this failed to solve the problem of supplying an equal and accessible education for every child. Despite the ANC's promises of a free education for every child, this did not materialize. The post-apartheid government decided to encourage public schools to be supported by public funds. Fiske and Ladd (2004) showed that South Africa adopted a fees-based policy for a variety of reasons which included the limited availability of public resources and the pressure for local control over education. They argued that this ultimately led to a situation where race was replaced by class. This meant that children whose parents could afford to send them to good public schools (Model C schools) were provided with a school with sufficient resources, whereas children from lower socio-economic backgrounds did not necessarily benefit since their parents could not afford to pay school fees. The middle class children were still benefiting and the working class children who attended the previously disadvantaged schools were more handicapped since schools were battling to make ends meet with minimal school fees.

Another challenge with which the government was faced was developing a policy for this new system of education. This resulted in a number of active political and business groups coming to the forefront to participate in the structuring of this new educational policy, as reported by Jansen (2001). These were the trade union movement, the African National Congress (ANC) the apartheid state, the international aid community, the business community, the non-governmental organizations (NGOs) sector and the National Education and Training Forum.

All of these political and business groups contributed towards the policy after apartheid in some way or other. Therefore educational change had economic, social and political influences. Hence it can be argued that the teaching of school science has been "influenced by various political and pragmatic pressures and constraints" (Kind & Taber, 2005, cited in Taber, 2006:143).

Between the years 1994 and 1999 many new educational Acts of parliament were passed which included: the South African Schools Act of 1996, the Further Education and Training Act of 1998 and the Higher Education Act of 1997 which resulted in non-racial universities and schools, compulsory education for all children and the election of governing bodies in all public schools (Manganyi, 2001). The White Paper was another important document released in 1997 in which the government made a commitment to "equity, justice and a better life for all" (Moja & Hayward, 2001:118). The White Paper initiated the development of a new curriculum C2005 in 1997, which was subsequently revised. Currently the implementation of the Revised National Curriculum Statement continues to base its Learning Outcomes for the General Education and Training for Grades R-9 on the Critical and Developmental Outcomes that were encouraged by the South African Constitution and developed in a "democratic process" (DoE, 2002c:1).

An outcomes-based approach was favored due to the lack of confidence in the traditional methods of teaching and training, which were content-based (DoE, 1998b). Within the old content-based system, "assessment was largely summative, norm-referenced", aggregative and "judgemental in nature" (Killen & Vandeyar, 2003:122). It emphasized factual knowledge and content; learners were assessed individually; it was largely driven as a need to prove that assessment had taken place to the relevant authorities and placed little emphasis on critical thinking skills or on the needs of the individual learners (Killen & Vandeyar, 2003).

Five of the Critical Outcomes (COs) stated in the Revised National Curriculum Statement, which pertain to the present study, are given as follows. Learners should be able to:

- identify and solve problems and make decisions using critical and creative thinking.
- collect, analyse, organize and critically evaluate information.

- communicate effectively using visual, symbolic and/or language skills in various modes.
- use science and technology effectively and critically, showing responsibility towards the environment and the health of others.
- recognize that problem solving contexts do not exist in isolation. (DoE, 2002c:1-2).

Three of the five Developmental Outcomes (DOs) stated in the Revised National Curriculum Statement (DoE, 2002c:1-2) pertaining to the present study, are that the learners should: "reflect on and explore a variety of strategies to learn more effectively"; "participate as responsible citizens in the life of local, national, and global communities"; and "be culturally and aesthetically sensitive across a range of social contexts".

Each of the three Learning Outcomes for Natural Science and Technology, LO1, LO2 and LO3 (DoE, 2002c:6) – emphasizing scientific investigations; constructing science knowledge; and science, society and the environment – represents, to a certain degree, the attainment of the Critical and Developmental Outcomes.

The RNCS (DoE, 2002c) states that the new curriculum endeavours to promote values that are important for personal development. The kind of learner that is envisaged is one whose actions will enhance a society based on respect for "democracy, equality, human dignity, life and social justice" (DoE, 2002c:3). The document also identifies the important role of teachers which hopes "to create a lifelong learner who is confident and independent, literate, numerate, multi-skilled, compassionate", with a high regard for the environment "and the ability to participate in society as a critical and active citizen".

Although huge efforts have been made since 1994 to achieve equity in the education system, the gap created by the apartheid system is too great to overcome within a short period of time. The legacy of the apartheid system of education has resulted in a large number of under-qualified science and mathematics teachers; a lack of proper facilities; and there is still a high learner-teacher ratio in the majority of South African schools. The unfairness of the old government is evident in that the majority of learners in South Africa have been receiving sub-standard education (Sadeck, 2003).

Consequently, the current government is faced with a huge task to remedy the past situation. However, certain major decisions concerning the rationalization of teachers and the immediate implementation of a new education system have worsened the situation since classes are still too big and the number of teachers in specialist subjects like mathematics and science has dropped.

The National Education Policy Act of 1996, cited in the Draft Assessment Policy in the General Education and Training Phase Grades R to 9 and Adult Basic Education and Training (ABET) of 1998 (Government Gazette No. 18998), states that:

> ... the Minister shall direct that the standards of education provision, delivery and performance throughout the Republic be monitored and evaluated by the Department annually or at specified intervals in accordance with the object of assessing progress in complying with the provisions of the Constitution and with national education policy... (DoE, 1998a:33)

Prior to the introduction of the Act, there was no systemic monitoring of the quality of the education system, except for the matriculation examinations. At present the main objective of systemic evaluation is to assess the extent to which the vision and goals of the educational transformation process are being achieved by the education system, with particular reference to the General Education and Training (GET) and Further Education and Training (FET) phases. It is also seen as a means of monitoring standards. This will provide adequate and relevant information which can assist in the formulation of policies and programmes for a qualitative improvement of General and Further Education and Training band. Lastly, it is seen as a means to determine the strengths and weaknesses of the system on a periodic basis. This can be achieved by providing feedback to all the participants in the system so as to put in place processes and structures that will assist in providing remedial measures to address the weaknesses. At the same time note can be taken of the strengths to see how these could be used to improve the system.

This new educational transformation has had a great influence on teachers and their teaching performance. For example, teachers have had to prepare tasks with learning outcomes, assessment criteria and rubrics and these have required time and knowledge. According to Welton (2001), transformation required that all stakeholders - which included learners, teachers and managers – should have understood the new learning and teaching practice. Teachers required major training to understand the new approach to teaching and they needed to learn new skills and attitudes to learners.

They needed to develop a practical understanding of what the new policies were; how they could be implemented in practice, and how learning and teaching could be managed in ways appropriate to the new paradigm. This meant that teachers had to be familiar with the new policy documents and to be able to interpret them. Sayed (2002:29) believed that there was a "mismatch between policy intention and policy practice" which meant that teachers were either not interpreting the new policy practice or that the policy documents were too implicit.

Another factor that should not be ignored during any transformation period is that each school deals with change differently. Some schools are equipped and can cope with change immediately, while others are not prepared for change due to limited resources and under-qualified teachers. Contrary to this, efforts to implement C2005 assumed that all schools were essentially the same and therefore all would benefit from the same kind of training and implementation strategy. This argument has been highlighted by Rogan (2000:119) who stated that "the process of change is an intimate affair that will play out differently in each and every school"; in other words it is context-specific.

Consequently, it is an aim of this study to determine how Grade 9 learners from different schools – which are categorized according to their level of socio-economic status (SES) - performed on the 2004 Natural Science CTA. Follow-up studies could determine how each individual school type experienced the CTA, through interviews with teachers and learners. The present study also looks at performances on each item and overall performance, but it does not classify each subsequent interview according to school type.

From the above discussion, it is quite evident that a variety of schools have developed because of apartheid, due to geographical location and socio-economic background. Hence I have consciously sought the inclusion of schools from different socio-economic backgrounds in order to analyse the nature and extent of their differences in performance.

1.6.2 Issues of accountability in assessment

As a 'high stakes' assessment, the GET certificate would be viewed as the exit point of Level 1 of the NQF, and as a pre-requisite for admission to the Further Education and Training band (Level 2 of the NQF). According to Wilmot (2004), the issue of accountability took on several new proportions. Wilmot believed that the results of the GET assessment would provide the state with information relating to the schools' and the state's performances in relation to the expected national standard (especially if these results were published). With the result, plans to improve performances of under-achieving schools would be initiated as done in the United Kingdom (Wilmot, 2003).

Wilmot (2004: 11) pointed out that one should also "be sensitive to the context and circumstances of schools", given the wide range of schools. This meant that the socio-economic status of schools should be taken into account. Examiners in Britain attempted to resolve the potential unfairness of absolute raw scores that did not take into account the background and circumstances of schools by producing "benchmark data" which categorised schools, so that similar schools were compared, according to Tate who was the chief executive of the qualifications and curriculum authority at the time (Tell, 1998:67). In the present study, schools were categorized according to school fees levied so that a fair analysis could be made. The issue of accountability can be reviewed only by an analysis of learners' performances among different schools. However, there are many factors that influence learners' performances. Although accountability is not the focus of this study, the outcome of the analysis may substantiate the argument concerning whether schools which are under-performing are to be held accountable or not.

Wilmot also reviewed the issue of accountability with regard to both the state and the public. Wilmot referred to Tell (1998) and his impression of accountability. According to Tell (1998), schools would be obliged to maintain a good standard and therefore would be kept alert as under-performing schools would be identified.

At present, school teachers and principals are kept alert by regular moderation meetings, where results and assessment tasks are scrutinized among teachers from other schools and by a subject advisor. In this manner a certain standard is monitored and teachers are obliged to develop a good standard. However, many factors contribute to teachers not assessing the way they should. A recent study conducted by Singh (2008) to determine whether or not 15 teachers in rural secondary schools were coping with outcomes-based assessment has revealed that the Natural Science learning area was not properly taught and assessed by teachers due to poor preparation caused by a heavy workload. Thus accountability can be viewed as something good that will or should improve the educational standard of schools. Cameron Dugmore, the Minister of Education and Culture in the Western Cape, has stated that schools were to be held accountable for their performances, while support for underperforming schools would be offered (Mangxamba, 2006:1-2). In the latter case, if the new system is not achieving its goals, its credibility and legitimacy would be challenged, i.e. the state would be held accountable to the public.

The negative side to accountability is described in a study by Whitford and Jones (2000). In Kentucky the state legislated performance based testing for all schools for accountability purposes. This system rewarded those schools that were doing well and teachers were rewarded with a salary bonus. However, those schools that did not improve over a two year cycle were to be held accountable and teacher and administrators were monitored. They argue that linking accountability to assessment results in major repercussions. In the present situation in South Africa, these effects of national testing are very similar to those mentioned by Whitford and Jones (2000). For example, great pressure is put on learners to do well in these tests and teacher-learner relationships have been weakened. Although teachers are forced to teach what the state has agreed upon, teachers have to concentrate on skills outlined by others. This adds extra pressure on teachers and as a result they tend to ignore the needs of individual learners. Since teachers have been told what to teach and the pressure of performing is high, it seems that the joy of creative teaching has diminished since teachers have already been told to concentrate on the content areas of assessment. These criticisms have been supported by Whiford and Jones (2000), who believed that teachers and principals are stressed in attempting to improve marks.

Tate, in an interview (cited in Tell, 1998:66), argued that "the public naming and shaming is painful – schools suffer, teachers suffer, the reputations of schools suffer as well – but, on the whole, it seems like a sensible crisis response to a crisis situation".

Accountability therefore has advantages and disadvantages. In the former case, staff members in schools are made aware that their actions as far as assessment and teaching are concerned will be monitored. As a result, principals are obliged to keep a watchful eye on teachers' methods and assessment tasks to uphold their school's reputation. In the latter case, accountability for learners' results can cause stress for teachers and principals who are striving to teach amidst discipline problems, a heavy workload and bigger classes. Also accountability for performance could result in teachers developing any form of testing to develop test scores. Although this present study does not look at these factors in particular, it is reported to be a significant problem and should be investigated further.

1.6.3 Preparation issues

In South Africa, officials in the Department of Education decided to postpone the GET certification process until the end of 2004 in order "to build capacity within the system; to prepare teachers and learners for the assessment of outcomes; trial and develop recording and reporting procedures" (Independent Examinations Board, IEB, Circular No 41/2002, cited in Wilmot, 2004:12). However, this postponement was necessary to make certain that the new educational system was able to be implemented without any problems (Wilmot, 2004).

1.6.4 Performance level issues

Performance level or learner achievement, as described in the Government Gazette (DoE, 2003c), recommended that learners' marks be converted to percentages and then to level descriptor codes so that they could be reported to parents.

According to Wilmot (2004), the percentages required for academic attainment, at Levels 1-3 of the four-level grading system for schools, had been lowered. For example, the performance range for Level 3 ('achieved') had been changed from 50%-69% to 40%-69%. This level category has dropped considerably and has been regarded by many teachers as a lowering of standards. Wilmot (2004) interpreted this as a "strategic move by the state to reduce the risk of potentially high GET failure rates" Wilmot (2004:12). This, she believed, meant that the state had poor confidence in the new education system. Also, the lowering of GET levels, especially in South Africa, whose learners performed poorly in the Third International Mathematics and Science Survey-R [TIMSS-R] of 1998/1999 (Howie, 2001), suggested a "regression in terms of educational standards in South Africa" (Wilmot, 2004:12).

1.6.5 Issues of promotion

The South African General Education and Training Certificate document (DoE, 2000:13) described the promotion of Grade 9 learners on the policy basis of learners demonstrating competences that reflected a balanced and "weighted spread over all eight learning areas, through the combination of an institution-based continuous assessment programme and an external summative assessment component". According to the document, the learner was to be promoted if he/she satisfied the requirements of both the school-based assessment and the external summative assessment. It mentioned that the school-based component of continuous assessment (CASS) was to constitute 75% of the final result and this was to be moderated externally. The external summative assessment was to constitute 25% of the final result and was to be conducted through an instrument known as the Common Tasks for Assessment (CTA), set for each of the eight Learning Areas (DoE, 2000). Section A contributed 60% towards the CTA and Section B contributed 40% towards the CTA (DoE, 2002b). The document (DoE, 2000) also described the role of the Council for the General and Further Education and Training Quality Assurance (UMALUSI) which was to provide mechanisms for assuring the standard of both CASS and the CTA at the national level.

Currently, the CTA can be regarded as a form of 'systemic assessment'. In 2003 the DoE and the Independent Examinations Board implemented a series of CTAs in the GETC nationally for the first time. According to the South African Policy Framework for the Assessment and Promotion of Learners in Grade 9 (DoE, 2003a), the CTA examination was to be set externally by the DoE in collaboration with the Provincial

Departments of Education and marked internally. Therefore my current research study analyses the outcomes of the implementation of the Natural Science CTA of 2004. The Assessment Policy for Grades R-9 (Government Gazette 1998), cited in the Government Gazette (DoE, 2003c:8) stated that moderation should be "carried out to ensure that appropriate standards are maintained in the assessment process" and that "the CTA will also serve as a validation tool for CASS".

1.6.6 Problematic issues in assessment using CTAs

According to Muller (2004:235), problems arose in the development of the instruments because the "under-specification of C2005 provided no common content on which to base the tasks". Although it was the aim of the CTA to test skills more than content, skills and content were very difficult to separate. As a result, the external examiners themselves had to develop Section A that included the necessary content required by learners and teachers for them to answer Section B (Muller, 2004). This resulted in the CTA being too long because of the content. This would have been avoided, had C2005 (DoE, 2002c) been more specific in describing content, which is something to which I will refer in Chapter 4. Problems also arose which involved the translation, distribution and training of the teachers in the CTAs (Muller 2004). Only certain schools wrote the 2003 CTAs as they were not compulsory back then.

Hence, in this dissertation it was anticipated that an analysis of the 2004 Grade 9 Natural Science CTA results, and the interviews with Grade 9 teachers embedded in the changes, might also reveal any implementation problems with regard to the CTAs.

1.7 The purposes of the research and its research questions

The focus of the current study was on investigating the responses of conveniently available diverse classes of learners, who attended schools of different socio-economic status based on school fees as indicators, to Section B of the 2004 Grade 9 CTA Natural Science test paper, two hours long, a copy of which is reproduced in Appendix I. The learners' performance scores in the Western Cape were readily at hand for the purposes of the initial quantitative investigation and the qualitative development of subsequent interviews, which were to:

- identify concepts in the test items that the learners had difficulty in answering;
- identify any process skills in which the learners underperformed;
- judge whether the CTA test paper as a whole might be too easy, too hard, or at a reasonable level of difficulty;
- discover whether misconceptions or misinterpretations were evident in the learners' responses to individual test items in the Natural Science CTA;
- measure and try to account for differences in CTA performance score means between groups when they appeared to be associated significantly with differences in gender, levels of socio-economic status (SES) and home language;
- detect whether there were shortcomings in the design and wording of the CTA; for example, with regard to layout, ambiguity, clarity, appropriateness for RNCS (DoE, 2002c) and diagrammatic representation;
- make evidence-based recommendations for the future use (or discontinuation) of CTAs in Natural Science as a form of mass-testing at the Grade 9 level;
- record, analyse and explain problems encountered by local schools; and possibly, discuss and evaluate the soundness of selected national curriculum statements.

This study has not looked in depth at each possible contributory factor that may have influenced learners' performances. Instead it provides the reader with disclosed problems associated with the implementation of the CTA. It judges the CTA as a potential tool for assessment in the South African context and provides suggestions and recommendations for future CTAs and their implementation.

Hence, in pursuance of the aim of the study, answers were sought to the following questions:

1. How did a sample of 1572 learners and their teachers experience the 2004 Grade 9 Natural Science Common Tasks for Assessment (CTA), Section B, as a potential instrument of performance and educational achievement?
2. Why did the learners perform in the ways that they did, and what deeper insights into the learners' achievements on the CTA were gained when their responses were analysed?

The more detailed derived **auxiliary-questions** pertaining to a range of schools and contextually-based variables are set out comprehensively in Chapter 3.

1.8 The importance, significance and value of the research

It is anticipated that the findings of this investigation may be of potential value to future learners, teachers, curriculum planners and CTA examiners. In addition to identifying performance strengths, this study has engaged in identifying and selecting certain CTA-related aspects in the teaching and learning of science across schools such as learners' misconceptions, lack of skills, misinterpretations and inadequate 'prior knowledge' that might hamper their further understanding in higher grades. The findings emanating from this study may be valuable in that they could inform science teachers of the common problems that their learners encountered, as well as their learners' positive accomplishments. If the learners participating in this study were found to hold inadequate and widespread conceptions of certain concepts in science, it seems probable that many present and future Grade 9 learners might also hold similar misconceptions. The findings of the study might also prove to be informative and useful to science teachers in the design of their future lessons and instructional practices. In other words, by identifying and documenting the problems that learners appear to have experienced during the past few years (with some of these local findings linking to those of other previous studies), cognisance may be taken of these specific aspects of learning to try to alleviate the inconsistencies where they appear to prevail among the schools.

Past studies elsewhere have also revealed statistically significant differences in the performances of learners based on their grade level, school type, student type and socio-economic background (SEB); e.g. the learners from high SEB schools have tended to outperform those from low SEB schools (Ainley, Graetz, Long & Batten, 1995; Beaumont-Walters & Soyibo, 2001). Such findings may be used to justify the future funding of compensatory intervention programmes or bridging action in schools.

It is hoped that this study will also be of benefit to curriculum planners and CTA examiners by imparting information derived from an in-depth analysis of learners' responses to test items and questions - with regard to noting test designers' possible shortcomings in: layout, degree of abstraction; ambiguity, content appropriateness for the RNCS (DoE, 2002c), diagrammatic representation, and the validity of the test items examined.

Because the CTAs were implemented fully in schools only in 2004, when they were written nationally as an external examination, many problems were expected to surface; and so in this study I have attempted to identify these problems. Therefore it is hoped that the recommendations supplied or discussed at the end of the dissertation will be of value to the development of possible future external CTA tests, for educational use by teachers and curriculum planners.

1.9 Clarification of terms

- **Outcomes-based Education (OBE)**

An outcomes-based education is aimed at providing all learners an opportunity to achieve to their highest ability. This is accomplished by a set of outcomes which is stipulated as the process which favours a learner-centred and activity-based approach to learning (DoE, 2002c).

- **Outcomes**

The "results at the end of the learning process in outcomes-based education; these outcomes help shape the learning process" (DoE, 2002c:86).

- **Assessment**

"A continuous planned process of gathering information on learner performance, measured against the Assessment Standards" (DoE, 2002c:3).

- **Common Tasks for Assessment (CTAs)**

"Common Tasks for Assessment may be set at national, provincial, district or cluster level, are conducted at school level, and are moderated externally" (DoE, 2002c:79).

- **Assessment Standards (AS)**

Assessment Standards "describe the level at which learners should demonstrate their achievement of the Learning Outcomes(s) and the ways of demonstrating their achievement" (DoE, 2002c:76).

- **Science process skills**

"The term 'process skills' refers to the learner's cognitive activity of creating meaning and structure from new information and experiences. Examples of process skills include observing, making measurements, classifying data, making inferences and formulating question for investigation" (DoE, 2002c:13). The skills investigated in this present study have been identified and listed in Chapter 3, pages 73-74.

- **Model A, Model B and Model C schools**

Model A government schools are those that were previously referred to as the race-based 'white' schools administered by the House of Assembly (HOA) and whose parent bodies decided not to admit learners of other races.

Model B government schools are those that were referred to as the former racially 'coloured' and 'black' schools administered under the House of Representatives (HOR) and the Department of Education and Training (DET), respectively.

Model C schools are those that were referred to as the former race-based 'white schools' which fell under the House of Assembly (HOA) and whose parent body decided to admit students of all races from 1990 onwards (Fiske & Ladd, 2004).

- **Socio-economic status (SES)**

In this investigation the relative socio-economic status level of a school has been defined and ranked in terms of the magnitude of the school fees levied (Attwood, 2003).

1.10 Methodology: The research approach

The research approach adopted in this investigation was selected to enhance in-depth explanation, and so utilized a multi-dimensional combination of qualitative and quantitative methodologies. The implementation of the research strategies developed procedurally through four phases and, during each phase, various research methods were used. These are summarized as follows.

Phase 1 involved a review of the literature, the generation of a provisional focus question and a pilot study which was conducted using an *ex post facto* research methodology. During this phase the first data-gathering instrument, the 2004 Natural Science CTA was accepted for investigation and the outcomes of the pilot study were summarized.

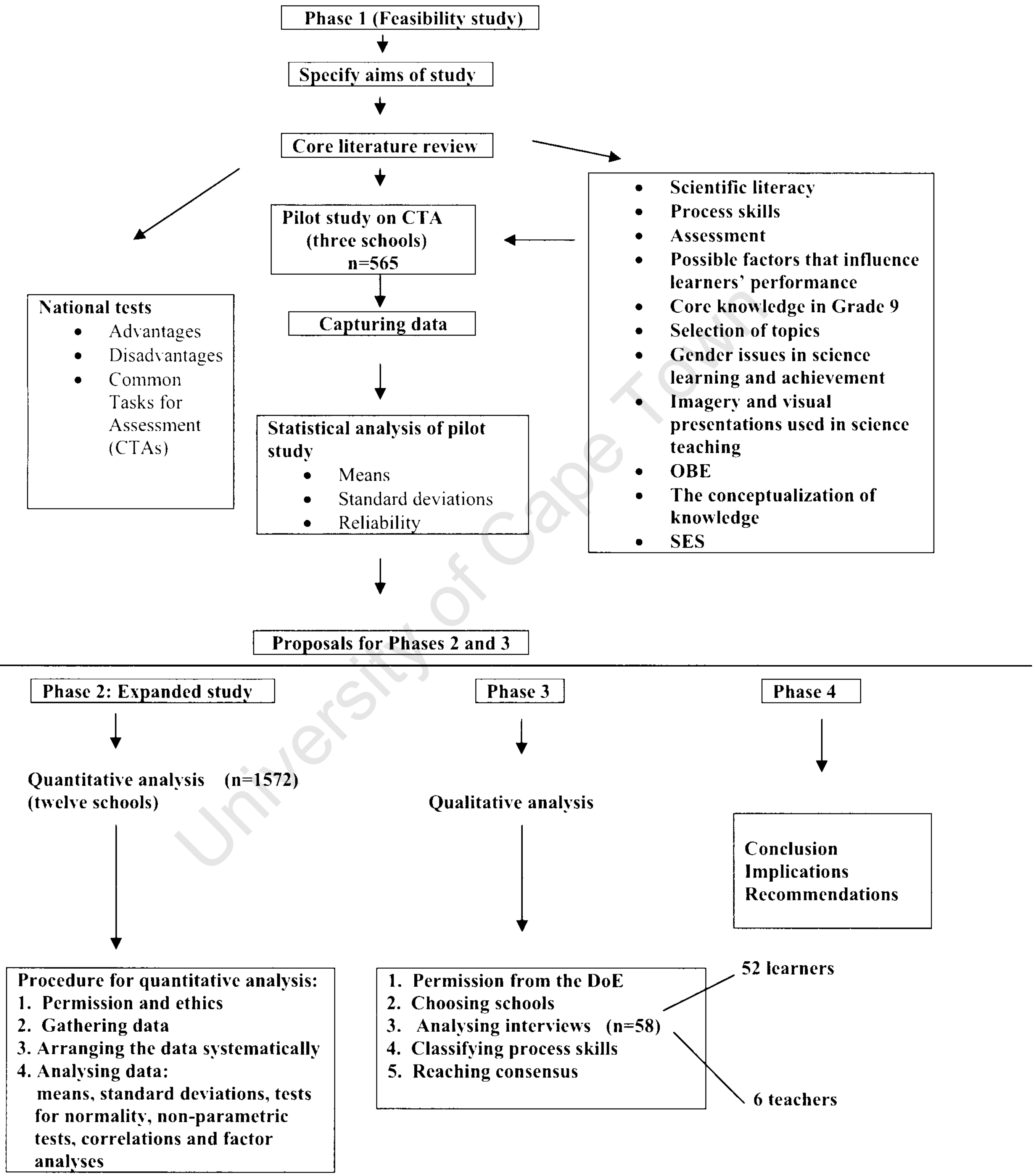
Phase 2 then derived and clarified two focus questions; and presented a number of quantitative and auxiliary research questions; it described the samples of schools selected for the enlarged study; it listed the dependent and independent variables; and it outlined the intended analytical research tools – such as the calculated means, standard deviations, tests for normality, the appropriate selection of either parametric or non-parametric tests, correlations and factor analyses.

Phase 3 of the investigation focused on the design and implementation of the qualitative follow-up interviews; and it described criteria for the selection of the six participant teachers and 52 learners. Their contexts were also noted. Then a process of triangulation was adopted as a research strategy for possibly confirming or explaining the quantitative results and for developing analyses, inferences and linkages from the results in the context of the work of Green and Naidoo (2006), Reddy (2006a), Siebörger (2004), Taber (2006) and Wilmot (2004),

Phase 4 of the present study generated the research conclusions, implications and recommendations.

Figure 1.1 represents the flow diagram of the structure and development of the thesis.

Figure 1.1: Flow diagram of the structure and development of the thesis



1.11 Motivation for the study

Many circumstances and factors prompted and motivated this study. However, two of the most important were as follows:

- **The importance and significance of CTAs for teaching and the curriculum**

As a teacher, I was under the impression that the implementation of the innovative CTAs in 2003 seemed to have evoked mixed feelings – mainly negative – among teachers, parents and students. A report produced by Wilmot (2004) also motivated this study. Only after a piloted Human and Social Sciences (HSS) CTA had been trialled in 2002 - at the Diocesan School for Girls and at St. Andrew's College in Grahamstown - were the local history and geography teachers prepared to implement and evaluate the CTA in their schools in 2003. Wilmot's (2004) report documented the process through which geography and history teachers and an education lecturer implemented and analysed the first national application of continuous assessment (the CASS) and the CTA for the General and Training Certificate (GETC), in which the CTA results were also analysed.

This present study, although conducted differently, has also attempted to give a comprehensive account of the many facets of the implementation and outcomes of the CTA as an innovative educational intervention. It has attempted to provide a selective but detailed analysis of 2004 CTA performances in Natural Science and it has outlined possible extrapolated shortcomings in the curriculum and in teaching methods with regard to certain concepts and process skills, and in the content and structure of the CTA itself, in order to feed results from the study directly into both institutional teaching and the curriculum development processes.

- **The previous experience of the researcher with teaching the Natural Science CTA**

My experience with teaching Natural Science at the inception of OBE – with its emphasis on process skills, Learning Outcomes and Assessment Standards – and my teaching the 2003 Natural Science CTA motivated me to undertake this study. My interest in the teaching of process skills and its emphasis in the curriculum initiated a literature review (Beaumont-Walters & Soyibo, 2001; Donnelly, 1987; Rollnick, Lubben, Dlamini, Lotz & Irving 1999; Sadeck, 1999; White, 2003), the findings from which seemed to resonate with my teaching experience. This indicated that many learners and teachers had experienced problems with acquiring and learning certain process skills.

1.12 Assumptions of the study

I have assumed that in 2004 the learners were taught CTA Section A thoroughly prior to their attempting to answer Section B which has been formally analysed in this current study. I have also assumed that the learners' CTA (Section B) answers were marked fairly and professionally by all teachers using the memorandum supplied to them for this purpose. Another validity assumption was made relating the presumed SES level of a school and its community to the amount of the school fee levied annually.

1.13 Limitations of the study

The enlarged, comprehensive study presented in Phase 2 of this investigation was limited to learners from twelve schools in the Western Cape who were willing to offer their performances on the Natural Science CTA for analysis. Although the schools differed in socio-economic status, the learners in the twelve schools were predominantly English- and Afrikaans-speaking. Therefore the sample was not fully representative in terms of language. Only 17% used English as a second language. For at least some of these students the CTA language of presentation might have acted as a partial barrier, and this possibility was considered to be a limitation in the research methodology.

In 2004, both Section A and Section B of the CTA were presented and answered by the learners in either English or Afrikaans only.

There were other possible limitations. For example, not all school principals initially approached were enthusiastic and therefore several did not allow me to analyse their

CTA scripts. Furthermore, some of the answers in the CTAs were not completed by all learners because of time restrictions.

1.14 Chapter summary

In this chapter the research problem, its origin, context and background have been clarified and its purposes and significance stated. The aims of the research, key terms and limitations of the investigation, research questions, assumptions and variables have been presented. The literature on performance testing, continuous assessment and common tasks for assessment and outcomes has been introduced. The research design and methodology have described the data-gathering phases and procedures; and the initial treatment, processing and methods of analysis of the data have been indicated.

1.15 Organization of the remainder of the dissertation

The next four chapters have been arranged as follows:

Chapter 2 presents the relevant literature review in three sections; Chapter 3 explains in more detail the methodology, design and implementation of the research process; Chapter 4 presents the results and discusses the findings of the research; and Chapter 5 draws conclusions and implications and makes recommendations based on the findings and the discussion of these results.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature review is presented in three sections. Each section is derived from and links to the title of the dissertation and to the research questions specified in Section 1.7 of Chapter 1 pertaining to the Natural Science CTA.

The first section of Chapter 2 presents an overview of current issues and debates in the field of school academic performance testing and assessment. The second section introduces factors that have been identified as possibly influencing learners' academic performance. The third section describes assessment in the context of the Common Task for Assessment (CTA) in South Africa and also reveals some literature-derived problems related to the implementation of Common Tasks for Assessment in the classroom.

2.2 Constructivism and assessment

Constructivism is a theory of learning that has had significant influence on science education research, teaching and learning at all levels. It has been viewed as having the most obvious influence on the science curriculum since 1980 (Fensham, 1992). Constructivism is based on the belief that humans construct knowledge, more particularly scientific knowledge, personally and/or socially on the basis of what they already know. Driver, Squires, Rushworth and Wood-Robinson (1995:2) reports that "children have ways of construing events and phenomena which are coherent and fit with their domains of experience…". They believed that childrens' experiences are often sensory and can result in the development of a conception that differs from the scientific explanation, *viz.* "alternate conceptions", "misconceptions", etc.

From the social constructivist perception, the learner and social influences cannot be separated (Palincsar, 1998; Wertsch, 1997). Thus it is important to take into account the social background of the learner since it has an affect on the learner's performance. According to Vygotsky (1962), cited in Black (1999), learning is strongly related to the social context that it takes place in and the discourse within the learning environment. Therefore there is a strong link between the assessment used and the outcomes. With this in mind, it has been argued that assessment should be carefully implemented to avoid any form of bias pertaining to gender, social, ethnic and linguistic groups (Black, 1999). It is partly in the light of this theory that this study is based on social constructivism.

This study looks at the CTA in relation to learners' performances. The CTA framework document states that Section B "reflect a transfer of skills from section A" and "assesses individual competence" (DoE, 2002b:10). This study will judge the standard of the CTA by identifying the level of competences used in the CTAs based on the application of the various process skills identified, classified under these competence levels. It will also judge the quality of the CTA by looking at reasons for learners' performances. It is not a complete criticism on the CTA but identifies its strengths and weaknesses as a tool for assessment.

The particular part of the education system of interest for this study is the curriculum and its nature. Thus it was necessary for this study to borrow from Green and Naidoo's (2006) framework, based on competence levels and process skills. Their framework was relevant to this study in that it classified the various process skills which have been emphasized in the curriculum (DoE, 2002c) and which will be identified in this study, underneath each different cognitive competence level. In this manner, the strengths and weaknesses of competence levels of different learners could be judged according to gender and type of schools.

Also, what is important to this study are the four aspects of the curriculum. The intended curriculum (the intention of the educational system); the implemented curriculum (instructional practice); the perceived curriculum (learning experiences by the learners) and the achieved curriculum (the outcomes of learners) as defined by Mills and Treagust (2002), cited in Bansilal (2008) and Reddy (2006a). The above four aspects will provide a greater insight of the results in terms of whether the noble intentions of the department has been achieved or not and whether or not there is an identifiable mismatch of the intentions of the intended curriculum and the implemented curriculum on the one hand and the perceived and achieved curriculum on the other hand. The inter-relatedness of these ideas will be revealed in the results and discussion.

The CTAs were used as an instrument to determine how learners performed. Whether there was any form of bias with regard to the instrument used would be ascertained or not. This study does not particularly focus on one aspect of possible bias but provides insights into possible factors that could have hindered the learners' performances, based on the above theory, results of the analysis, design of the CTA and past studies.

2.3 An overview of current issues and debates in the field of school academic performance testing and assessment

In this section, assessment is defined in various ways, and then its role in the educational system nationwide is discussed. It also elaborates on the purposes of standardised testing, criticisms levelled against standardised testing, issues in formative assessment, and finally how these all relate to the context of the present study.

2.3.1 Operational definitions

Assessment is and has always been an integral part of education. Classroom assessment can be used in a variety of ways. It can be used formally, which involves examinations and tests, or informally which involves observations and oral questioning (Shepard, 2003). Each type of assessment serves a particular purpose. For example, it can be used formatively, by providing positive feedback to learners to improve learning. It can also be used summatively to report on the achievement levels of learners.

To assess means to measure something in context. Black (1990:27) supported assessment with a quotation taken from the Task Group on Assessment and Testing (TGAT) report:

> Assessment is at the heart of the process of promoting children's learning. It can provide a framework in which educational objectives may be set and pupils' progress charted and expressed. It can provide a basis for planning the next educational steps in response to children's needs. By facilitating dialogue between teachers, it can enhance professional skills and help the school as a whole to strengthen learning across the curriculum and throughout its age range.

Shepard (2001) provides a detailed discussion on a reformed assessment based on social constructivism. She believed that assessment could only benefit teaching and learning through a constructivist approach. This paradigm shift is in contrast to a behavioural approach to teaching and learning. She argued that a behaviourist approach to assessment defeated its purpose in improving learning, since a learner's success in answering certain basic familiar skills were regarded as mastering a learning objective. She argued that this stalled learning of higher competence levelled skills like reasoning and problem solving skills. For a constructivist form of assessment to be implemented and practised, depended on the teaching approach and interaction of teachers with their learners. According to Shepard a more dynamic form of assessment integrates a constructivist theory, the reformed curriculum and classroom assessment.

From a constructivist perspective learning was "socially and culturally developed" (Shepard, 2001). This meant that children entered school with their own existing knowledge developed over the years through interaction with their parents and other adults. According to the theory of constructivism, knowledge is constructed (Shepard, 2001). Therefore eliciting prior knowledge from learners and taking into account their social and cultural background could enhance the learning process by providing information to teachers to rectify or build on this knowledge. Based on past research, Shepard stated that true understanding can only occur if learners are able to transfer skills from one situation to the next. Therefore it is important that learners have enough practice in a variety of skills and different situations.

This learning theory (social constructivism), initiated a new principle in a revised curriculum which believed that "all students can learn" (Shepard, 2001: 1095).

Therefore it is important to provide all learners with an equal opportunity to do challenging problems as well.

In order for the new theory to be compatible with teaching and learning, changes in assessment should be implemented in the classroom. These changes have been discussed by Shepard. They include: more thinking and problem solving skills and self assessment by learners so that they view assessment as a means to improve learning instead of viewing it as an end to a section and probing misconceptions through eliciting prior knowledge.

According to Bennett (2003:221), arguments around assessment have included issues "such as the form it might take, what should be assessed, the extent to which teachers should be involved, how often assessment should take place and what should be done with the data on learners' performances". One of the purposes of the CTA is to "promote a common standard", as emphasized in the RNCS (DoE, 2002c: 79). This purpose seemed to have broadened the debate (Bennett, 2003). Although there are many obstacles obstructing this form of systemic assessment, it can be used in a positive manner. It can be used to determine the strengths and weaknesses of learners by eliciting the knowledge, skills and reasoning abilities required to reach a common standard as revealed by this study. It can also be used to upgrade teachers' performance to teach to a certain standard by improving the use of formative assessment as agreed upon by Shepard (2003).

2.3.2 Purposes of national assessment and standardised examinations

National public examinations play an important role in education systems all over the world. For example, in Africa alone, at least 65 different school examinations are currently administered at different levels (primary, secondary or senior secondary) across 25 countries (World Bank, 2001). National public examinations are a key feature in the South African school system. These examinations include Grade 9, which marks the end of compulsory education for all children and Grade 12, which marks the end of formal schooling. Although countries may vary in their purposes for national examinations, common purposes are: "to control and monitor standards"; to "identify and select learners into the next grade level"; "to certify learners at the end of schooling"; and most likely to be used "as an accountability tool for teachers and schools" (Kellaghan & Greaney, 2003, cited in Kanjee, 2006:72; Shepard, 2003).

In the United States, three **purposes of assessment** were identified as follows: summative assessment – which provided a general idea of learners' progress at a given time; formative assessment – which provided feedback on learners' progress so that teachers could improve classroom practices and accountability - which attached "strong incentives and sanctions to performance on state and local assessments" (National Research Council, 1999, cited in Bell & Cowie, 2000:538).

In this study learners' results are analysed on their performances on Section B of the CTA, which is based on performance tasks done mainly in Section A. The CTA is a tool that can be used to improve learning if enough time is spent on formative assessment. According to Wiggins (1993), if performance assessment is used to improve learning then learners should be assessed on what is stipulated in the curriculum and feedback should be given immediately. He argued that if a state is only interested in the marks of learners for accountability purposes then it does not consider these principles.

2.3.3 A critique of standardised testing

Standardised testing internationally has been a common trend during the past few years in order to benchmark performances between countries. Research done on standardised testing has revealed that it has different purposes. For example, in America public schools administer annually more than 100 million standardised examinations (Weaver, 1996). According to Weaver, these include readiness tests, to determine whether a child is ready for school; screening tests, to determine if a child has a learning disability or gifted in any way; intelligence tests, which measure intellectual ability; and achievement tests, which measure a limited range of skills and content. There has been wide criticism against standardised testing. Weaver describes some of these criticisms as: bias in favour of the middle-class learners who have a culture and upbringing similar to that of test-makers; bias against females; bias against children of colour; bias against children from lower socio-economic backgrounds and bias against children who come from rural areas. Another argument against standardised testing, which Weaver mentions, is that it tends to diminish the curriculum. In many cases teachers tend to teach to the test, since they are concerned about their learners' performance, and so less time is spent on engaging in effective and meaningful learning (Weaver, 1996).

This study has investigated a form of standardised testing nationally in the Western Cape in South Africa. Compared to the many standardised tests done in America, which include mainly multiple-choice questions, the form of testing in this study was mainly performance-based testing, including varied tasks with a number of questions. The description of the questions will be discussed in chapter 3.

2.4 The 2004 Natural Science CTA and the conceptualization of knowledge at the Grade 9 level: the broader theoretical framework

One of the dimensions of this study was to analyse learners' performances and the factors that may have influenced their level of achievement. Therefore it was important to provide a description or breakdown of the conceptualization of knowledge at the Grade 9 level in order to establish the standard of the CTA and whether it was set for all learners or only certain learners who are above average. This framework could also help in identify certain inadequacies in learners regarding their competence levels which could have contributed to learners' performances.

The conceptualization of knowledge in the 2004 Natural Science CTA based on the Grade 9 Natural Science curriculum will now be described in relation to the theoretical framework of Green and Naidoo (2006). The analysis resulting from this study will be very informative to teachers and curriculum developers in terms of level of competences identified in the CTA and possible reasons why and how learners' performed. Green and Naidoo analysed and compared the contents of the Grade 10 Interim Physical Science curriculum document (DoE, 1995b), and the National Curriculum Statement (NCS) for Physical Sciences (DoE, 2004a), to investigate changes in knowledge valued in the policies. A multi-dimensional approach was used in analyzing the documents. However, I have only used certain parts of their framework that is related to this study. The NCS for Physical Sciences (DoE, 2004a) draws and builds on the model of Skills, Knowledge, Attitudes and Values (SKAV) developed in the Natural Science (NS) learning area in the GET (DoE, 2002c).

Similarly, the thrust of the three LOs in the Western Cape Education Department hybrid, which was an interim measurement for Physical Science; in the GET (DoE. 2002a) and in the FET for Natural Science and the Physical Sciences (DoE, 2004a) are virtually the same. Hence, I will now refer to certain parts of their study as a model to describe the Revised National Curriculum Statement (DoE, 2002c) and the Natural Science CTA.

Some competences should be assessed in the CTA tasks (Section A) and further tested in Section B. The following competences to be tested were: cognitive competences. meta-cognitive competences, social competences, affective dispositions and motor competences (DoE, 2002b:12). This present study will only look at the cognitive competences since the other competences can only be assessed through observation of learners.

Green and Naidoo's framework was designed to identify the degree of competence levels presented in the Physical Science documents. They used Verhage and De Lange's (1997) method of grading the cognitive level of competences. Below is a table of the classification of competence levels. The cognitive competences consisted of meta-cognitive competences, advanced cognitive competences and complex cognitive competences. Each competence level composed of a set of skills of which most were identified as process skills in the RNCS (DoE, 2002c). Since this study concentrated mainly on the performances of learners in the CTAs, the framework for cognitive competences was used as a good analysis to decipher the level of competences used in the CTA and learners' overall performances in them.

With regard to the cognitive competences, the lowest level concerned "the knowledge of objects, definitions, technical skills and standard algorithms" (Verhage & De Lange, 1997:15). In other words the simple cognitive competence level entailed rote learning, which was the main focus in the past apartheid curriculum. Questions based on these competences required learners mainly to recall, to define and to state any past knowledge. The middle level, classified in the table below (see Table2.1) required learners to use the process skills mainly emphasized in the Revised National Curriculum Statement (DoE, 2002c). It referred to the complex cognitive competences. For example: to predict, to hypothesize, to interpret, deduce, conclude.

and to generalize. According to Beaumont-Walters and Soyibo's (2001) classification of skills, the complex cognitive competences are mainly composed of integrated skills, which they classified as higher ordered skills with the exception of 'prediction' which they regarded as a basic skill (see Table 2.1). Hence, the middle complex cognitive level required learners to relate and integrate two or more concepts. The questions associated with such a level were not straightforward questions and allowed more than one answer. Learners were expected to be able to "read carefully, reason well and make decisions" (Green & Naidoo, 2004:75). The highest level involved complex matters such as scientific enquiry, scientific reasoning and scientific investigation (see Table 2.1). According to Green and Naidoo the highest level was represented by meta-cognitive competences and advanced cognitive competences

Some examples of cognitive competences coded at different levels of complexity are presented in Table 2.1. Each competence level has different process skills.

Some examples of DoE (2002c) sentences which I interpreted and coded in terms of complexity of competence, using the categories (i.e. different process skills) described in Table 2.1 are:

> ...identify and solve problems and make decisions using critical and creative thinking (*metacognitive*) (DoE, 2002c:1). The process skills, "identify" , "problem solving" and "decision making" is classified under metacognitive competence.
>
> ...the learner will know and be able to interpret and apply scientific, technological and environmental knowledge (*complex cognitive*) (DoE, 2002c:9). The process skills "initerpret", and "apply" are classified under complex cognitive competence.
>
> ...the learner can recall meaningful information when it is needed (*simple cognitive*) (DoE, 2002c:9). The process skills "recall" is classified under cognitive competence.
>
> ...the learner searches for information from books and resource people, generates products and questionnaires, collects data and materials from nature or industry, creates testable questions and fair tests, and explains conclusions (*advanced cognitive*) (DoE, 2002c:8). The process skills used here are: to "conclude", "arrange" data, and "report" information. These are classified under complex cognitive competence.
>
> "Do you think the children can use the plug for the TV to boil water in a kettle rated at 220 V; 1,5 kW AC? Give a reason for your answer." (*metacognitive*) (DoE, 2004b:3). Here the learner has to make a decision.
>
> "Which variable do they change (independent variable)?"
> Here the learner interprets information from the table to decide which variable will change (hypothesizing) (*complex cognitive*) (DoE, 2004b:5).
>
> "Give the conclusion the children reach using the graph of their results." Here the learner has to draw a conclusion (*complex cognitive*) (DoE, 2004b:5).

"List one advantage and one disadvantage for the children's family of using propane gas." Here the learner has to interpret information, make an inference and evaluate the line graph. (*complex cognitive*) (DoE, 2004b:10).

"Use the key given with the diagram and write down a balanced equation for the reaction that occurs when ethane burns."
Here the learner has to recall meaningful information e.g. the learner has to know what the ethane formula is from Section A. (*simple cognitive*) (DoE, 2004b:9).

"Can the TV be connected in series with the light bulbs?" Here the learner has to recall information on series and parallel connections (*simple cognitive*) (DoE, 2004b:3)

Table 2.1: Examples of cognitive and socio-affective competences coded at different levels of complexity (adapted from Green and Naidoo 2006:76)

Cognitive competences			
Meta-cognitive competences	Advanced cognitive competences	Complex cognitive competences	Simple cognitive competences
Creative thinking; critical thinking; holistic thinking; analytic thinking; entrepreneurship; scientific reasoning; and understanding.	scientific enquiry; problem solving; scientific investigation; construct science knowledge; work scientifically.	apply; predict; transfer; make decisions; plan; organize information; evaluate information; synthesize; hypothesize; communicate; analyse; design; identify; debate; explain; generalize; interpret; determine; distinguish; examine; arrange; calculate; deduce; conclude; compare; report; discuss; summarize.	observe; state; recall; draw; select; list; describe; note; define.

2.5 Issues of assessor competence

Each CTA, required self -, teacher – and peer assessment and this demanded a high level of competence in teachers both as assessors and curriculum developers. However, according to Wilmot (2004) this was not the case – most teachers were not equipped with the necessary skills which were needed to implement the new continuous assessment (CASS). I do believe that this problem developed due to lack of proper training for teachers and a transformation in education that was introduced by the same time that many teachers lost their jobs and took the package because of rationalization. This created more problems - for example; classes were bigger, teachers were stressed and more time was spent on disciplining learners. The advantaged schools, former Model C schools could afford to employ more teachers who were paid by the governing body. Thus many of their teachers were more motivated to learn the new skills since their classes were manageable. Although both CASS and the CTAs contributed towards the GETC, Wilmot believed that since CASS carried greater weight i.e. it counted 75% while the CTAs only counted 25%, validity and reliability questions would arise – e.g. Whether or not there should be "more externally controlled standardized assessment at the expense of CASS?" (Wilmot, 2004:8).

2.6 Possible factors that influence learners' academic performance in science

This section of the literature review introduces and discusses possible influences on academic achievement, performance and attainment in schools, namely: learners' socio-economic status; gender; and learners' ignorance and misconceptions in the particular science topics: electricity, graphs, imagery in chemistry, the interpretation of diagrams and technical terminology in language.

2.6.1 Socio-economic (SES) factors and performance

Socio-economic status seems to play a major role in mathematics and science achievement scores. This has been revealed by numerous research studies (for e.g. Beaumont-Walters & Soyibo, 2001; HSRC, 2005; Inal, 2002; Reddy, 2006a; Riddel & Nyagura, 1991; Rothman, 1997). Below is a brief description of these studies.

According to Rothman (1997), the links between various socio-economic factors and school achievement had been known for some time. In a study done in Australia, Rothman (1997:13) found that achievement according to SES differed according to different learning areas and grades.

Riddel and Nyagura (1991) found that students in Zimbabwean secondary schools who were attending high fee-paying (trust) schools, elite urban government schools and mission schools also scored better in mathematics and English achievement tests than students in the less well-endowed government schools and in schools established by local councils.

Rowan (1999), cited in Porter and Smithson (2001: 63), found that for many schools in their sample "prior achievement and SES accounted for as much as eighty percent of the variance in mean achievement among classrooms".

Beaumont-Walters and Soyibo (2001) reported on a study conducted with 305 Jamaican learners to determine their levels of performance on five integrated process skills. This study was particularly important to the present study since it tested similar process skills classified under the middle level cognitive competences. They investigated Grade 9 and 10 learners' performances linked to gender, grade level, school location, school type, student type and socio-economic background (SEB). They found no significant differences between boys' and girls' performances and there were no links between the learners' gender and school location and their performance. However, they found that the learners from a higher SES outperformed learners from a low SES.

Inal (2002) also found that Cape Town science learners attending several schools with a lower SES achieved significantly below several schools of higher SES. Another interesting finding in Inal's study, which this study will attempt to investigate, is that English second language learners performed better in higher socio-economic status schools than lower socio-economic status schools.

Although the level of socio-economic status of the learner's school played a pivotal role in learner achievement, there were many other contextual factors that seemed to have also contributed to their performances. Among these issues were: learning environment at home – where successful learners had a wealth of information to use; absenteeism - learners who had a good school attendance performed better; and school resources - learners achieved better in schools that had sufficient resources compared to schools that had insufficient resources (Reddy, 2006b). Other factors were: active participation of learners in class; class size; parental involvement with the school; school donations; school discipline and educators' qualifications (HSRC, 2005).

In the study reported by Howie (2001), most of those Grade 8 learners participating in TIMSS-R who were, on average, older than the other participants, came from low socio-economic backgrounds. The South African learners performed below the international average in all content areas and it seems that socio-economic influences could have played a role in their performances.

In 2003 the Human Sciences Research Council (HSRC) conducted studies and tested Grade 8 and Grade 9 learners in mathematics and science in South Africa (Reddy, 2006b). Analysis showed that the large distribution was a reflection of scores of the continuing inequalities in education in South African society. A review of this South African national study in mathematics and science showed that performances of learners grouped according to categories reflecting the former racially-based department of education indicated that learners in the African schools (DET) had the lowest mean scores and learners in the former White schools (HOA) had the highest mean scores. Learners in the latter schools had a score just below the international mean. These results suggest that the history of the past may have had an appreciable effect on the achievement of learners according to the demography of the schools and their socio-economic status. This meant that learners who attended schools of a lower socio-economic status performed poorly compared to learners who attended schools of a higher socio-economic status.

According to Reddy (2006b), there was no single cause of South Africa's poor and diverse performance. She stated that preliminary explanations would have to be linked with various complex and connected sets of issues which included the issues of poverty, lack of resources and infrastructure in schools, low teacher qualification and poor learning cultures in schools.

In a recent report on literacy for Grade 6 learners in the Western Cape, it was found that learners from historically disadvantaged communities performed very poorly – "twelve years after the demise of apartheid" (Mangxamba, 2006:2). The report released by the HSRC stated that there was a significant difference in the performances of learners between schools from different socio-economic status (SES) (HSRC, 2005). Only 0.2% of learners at "black" schools in the former Department of Education and Training (DET) attained the required level for numeracy. Those in formerly "Coloured" schools, (previously the House of Representatives), achieved only a 5.3% success rate; and only 19.9% of learners in formerly Asian schools (previously the House of Delegates) performed at the required level. However, 64% of learners at the formerly "White" schools" (HOA) attained the numeracy standard required for Grade 6. The report concluded that level of poverty correlated strongly with level of performance. The national HSRC report (HSRC, 2005) recorded that only 41% of 3156 Grade 6 learners attained the specified standard in Natural Sciences.

These findings comply with Vygotsky's theory which emphasized the link between social context and learning (Vygotsky, 1978). This led the researcher to investigate this issue by categorizing each school into a defined level of SES based on the individual annual school fees levy. In order to extend or to substantiate these earlier findings, the researcher also planned to conduct in-depth interviews with learners and teachers to determine what other factors could have contributed to their performances in the Natural Science CTA. None of the above mentioned studies used the CTA as an assessment tool.

2.6.2 Class size

One of the main criticisms against OBE in the present South Africa, which I as a teacher strongly support, is the unacceptable large classes compared to other countries, like Australia ((Malcolm, 2001). A study on Grade 8 learners in African countries revealed that there was a significant decline in achievement levels, from classes with fewer learners to classes with more learners (Reddy, 2006b). This meant that class size affected the performance of learners – the scores were higher where class size was smaller. It is a definite contributing factor to learners' performances. especially in the South African context where rationalization of teachers and lack of funding in education has created these large classes.

2.6.3 Gender and performance

Differences in performance between boys and girls have always been a matter of interest in research studies. The gap between boys' and girls' performances seemed to have narrowed over the years. Studies conducted by the Department of Education on 2002 matriculation results reveal that girls were performing equally well or in some cases better than boys (Perry & Fleisch, 2006). Although it is not the aim of this study to differentiate learners' achievements individually on the basis of race, a classification of the 2002 matriculation results revealed that there was a markedly better performance at Higher Grade in Mathematics and Physical Science by Indian and White female candidates. Perry and Fleisch (2006) reported that African boys outperformed African girls, both in the number of candidates participating and in the percentage that passed. They also said that tentative explanations emerged through studies which believed that girls were more mature and had better learning styles; girls had better communication skills; while boys tended to reject academic work and lacked reading skills. Perry and Fleisch (2006) had no breakdown between the chemistry and physics questions and the performances of girls and boys in each section.

According to Howie (2001), the Third International Mathematics and Science Survey (TIMSS) had revealed a significant gender difference in overall national performance with boys performing better than girls but there was no significant difference in mean performance by girls and boys in South African schools two years later. However, significant gender differences were observed in two content areas: Earth Sciences and Physics. On Physics, boys achieved an average of 5% higher than girls (Howie, 2001). Reddy (2003) reported that there were no gender differences in achievement among any of the groups in eleven countries, including South Africa, which were also categorised according to ex-racial departments The difference in boys and girls performances decreased, from TIMSS 1999 to TIMSS 2003, in ex-DET and ex-HOA schools (Reddy, 2003). However, in seven countries, the girls performed significantly better than the boys and in 28 countries the boys outperformed the girls, according to Reddy's report. It would have been interesting to see whether culture played a significant role in the difference of performance.

Sencar and Eryilmaz (2003) found in their study in which 1 678 learners participated in Turkey, that the differences in performances between boys and girls depended on the context of the question. They found that, for the practical type of questions, the males outperformed the females and in the theoretical questions there were no significant difference in scores between males and females. However, earlier studies had revealed that girls performed better than boys on practical tests which involved making and interpreting observations whereas boys did better at "applying physical science ideas" (Bennett, 2003:211).

Earlier research also revealed that boys tended to outperform girls in the physics section of science which included identifying variables and interpreting a circuit diagram (Bennett, 2003; Levinson, 1994).

Research has also attempted to reveal possible causes for differences in performance between boys and girls in science. Although it is beyond the scope of this study to review the research findings in detail, a brief outline of possible causes is relevant to this study. Regarding age and gender differences – the gender gap in science was found to appear at 13 years and narrowed at 17 years (Shepardson & Pizzini, 1994, cited in Sencar & Eryilmaz, 2003).

According to a summary based on past research by Bennett (2003), boys and girls seemed to differ in performances in science with respect to: content area; societal influences; cultural influences; school and teacher effects; the sex of the teacher; girls and boys perception of science; attitude towards science and the type of assessment used. For example, boys outperformed girls in physics compared to the reverse in biology and chemistry (Bennett, 2003). Also, regarding the type of assessment used, boys performed better in multiple choice questions and preferred a writing style to be "short and factual", whereas the provision of course work and project work which required "extended reflective writing" improved girls' marks more noticeably (Elwood & Comber, 1996, cited in Bennett, 2003: 209-210). This finding seemed to be supported by studies of Howie (2001) which revealed that girls performed better on more general topics, which needed more self expression, than boys who achieved better in factual knowledge.

Bennett (2003) stated that improvements in girls' performances were shown to be linked to changes in assessment techniques and that research on gender issues had identified features of successful intervention strategies. According to Bennett teaching science in a co-educational school should be approached with caution and certain major issues should not be ignored. Firstly, gender bias should be avoided, and contributions towards science development should include both male and female scientists. Secondly, a wide range of activities and assessment strategies should be used that would appeal to both girls and boys. For example – girls tend to have good linguistic and imaginative abilities and so activities relating to this type of assessment should also be used.

The first survey of the Organization for Economic Co-operation and Development/Programme for International Student Assessment (OCED/PISA, 2001), or 'PISA' survey, indicated that boys no longer had the edge in academic achievement over girls.

According to Bennett (2003), the earlier studies used multiple-choice questions to gather their data while the PISA study made use of open-ended questions. This implied that the performance depended on the nature of the assessment and the construct being assessed.

The above literature review extends Vygotsky's (1978) theory of social interaction and discourse. Vygotsky's theory of social constructivism identifies the link between learning and social processes, bearing in mind that knowledge is constructed through social interactions. Thus, every child has some form of prior knowledge which has been developed over the years through past experiences with their parents and other adults. With regard to gender the social processes would refer to the cultural and social differences between girls and boys. For example, past research has revealed that girls have good linguistic and imaginative abilities in comparison to boys who are better at revealing straightforward facts (Bennett, 2003). Thus it can be said that assessment should be carefully implemented to avoid any form of bias pertaining to gender. The above studies have revealed that the use of different kinds of assessment resulted in differences in performances between boys and girls, which meant that the context, content and style of assessment played a significant role in achievement between boys and girls (Black, 1999).

In conclusion, the literature review in this section has highlighted particular gender differences in performance with regard to certain sections of science and types of assessment. Hence, the present study will examine gender differences with regard to performances in different process skills by statistically analysing the CTA results of learners and whether the results are similar or different to previous studies. For example it was deemed interesting to know how learners performed according to gender within a certain age group (e.g. 14 -15 year olds) and within a certain school type based on socio-economic status in a South African context. The interviews conducted with learners and teachers also shed further insight about the assessment used.

2.6.4 Ignorance and misconceptions in science topics

It has been shown that the identification of misconceptions about certain science concepts is very important in the learning and teaching of science (Carmichael, Driver, Holding, Twigger & Watts, 1990; Pfundt & Duit, 1994). Therefore certain misconceptions and areas of ignorance have been identified in this study as well.

(a) Electricity

Electricity can be a relevant topic to learners from both urban and rural centres because it relates to their everyday lives, e.g. providing light, being used to boil water or cooking food, and operating many machines and gadgets. Nevertheless, there is still reason to believe that many learners do not have a valid understanding of certain concepts, since electricity is a challenging topic at all school levels. Learners very often have difficulty in learning this section.

Extensive research in schools has indicated that electricity is a difficult topic to understand and that many learners have a range of misconceptions regarding the topic (Arnold & Millar, 1987; Cohen, Eylon & Ganiel, 1983; Duit & von Rhöneck, 1998; Evans, 1978; Fredette & Lockhead, 1980; Hendricks, 1999; Psillos & Koumaras, 1988; Shipstone, 1985a, 1985b). There have been numerous problems related to the learning of electrical circuits. These have been concentrated mainly in:

- the lack of conceptions, where the learners cannot observe directly the quantities dealt with (Dupin & Joshua, 1989);
- the relative roles of the different quantities involved, especially current and energy, mainly with respect to potential difference and power (Rochford & de Jager, 1990);
- the diagrammatic representations of circuits and the visual perception of them (Pudlowski 1988); and
- the relationships between a whole circuit and its parts (Cohen, Eylon & Ganiel, 1983).

As mentioned earlier, studies have also shown that students' misconceptions regarding electric circuits could be influenced to a certain extent by students' gender, age, attitude towards the topic and prior experiences related to the topic (Sencar & Eryilmaz, 2003). Arnold and Millar (1994) found that another source of learning difficulty regarding electrical circuits was that the concepts concerned (current, voltage, resistance) were very abstract, theoretical ideas used to explain a range of observations. Added to that is the problem that the simplified circuits now commonly used in introductory courses of study are remote from children's experiences of everyday electrical applications, and might fail to serve as adequate models for them – thus preventing effective linkages between 'school' and 'everyday' knowledge.

After conducting an extensive literature research, the main difficulties emerging that learners seemed to have encountered in electricity were the following:

- Some students propose that, in a series circuit, current will be shared equally by all the components of the apparatus (Shipstone,1982, cited in Inal, 2002).
- Current flowing from a battery is thought to be constant and not affected by changes in the external circuit, i.e. students do not see it as a conserved quantity (Stanton, 1990).
- Many learners find great difficulty in discriminating between the notions of current and voltage (Evans, 1978).

- Students tend to confuse cause and effect, believing that voltage is dependent on current flow, and frequently they cannot comprehend why a potential difference can be maintained over a gap in the circuit (Shipstone, 1985a).
- Few students use the concept of 'voltage' in their reasoning to solve problems concerning an electric current (Stanton, 1990).
- Many students do not think that identical bulbs connected in series light up with equal brightness. With parallel connections, there is a tendency for some students to say that the current splits equally, irrespective of the resistances in the branches (Stanton, 1990).

Inal (2002) recorded that his students tended to over-generalise simple electricity problems sampled from physics texts. The students then applied these over-generalizations to new complex problems with negative consequences. Therefore it is important to teach learners many different cases regarding current, voltage, resistance, parallel and series circuits, and so on. If not, this could possibly result in learners being taught only special cases without informing them that many more cases existed.

Arnold and Millar (1987), adopted a constructive approach to teaching electricity by eliciting children's ideas and then building on those existing beliefs in attempting to produce accommodation towards the accepted scientific view. In their study, importance was attached to teaching the logical sequence most appropriate for learning, rather than trying to teach the logic of the subject matter as seen by scientists. In their introductory lesson, topics 'traditionally' included - namely voltage and parallel circuits - were omitted.

Research findings indicated that 'voltage' was a particularly troublesome concept, best introduced later in the secondary school years, after current had been grasped, using a few simple operating rules (Arnold & Millar, 1994; Shipstone, 1985b). Similarly no attempt to introduce branching (parallel) circuits was made in the introductory teaching. Past studies had shown that children experienced great difficulty in discriminating between current and voltage (Evans, 1978; Shipstone, 1985b). However, it has been argued more recently that the notion of voltage be taught alongside the concept of current so that the usual 'voltage equals current' idea – which appeared because of an early focus on current – be dispelled to make learners more 'voltage minded' (Driver, Squires, Rushworth & Wood-Robinson, 1995:122). Psillos, Koumaras and Tiberghien (1988), supported this suggestion and proposed a lot of measuring of voltage alongside current measurements. Psillos *et al.* (1988) believed that if the teaching of 'voltage' was to be introduced at the lower secondary level (Grades 8 and 9), then a conceptual model should be used to make learning easier. An appropriate conceptual model designed, presented and analysed by Psillos *et al.* (1988:33) included teaching about:

- the brightness of a bulb in a simple battery-bulb circuit;
- the brightness of a bulb in a series connection of two batteries to one bulb;
- the brightness of a bulb (and the duration for which it is lit) in a parallel connection of two batteries and one bulb;
- the volume of a battery and what it contains;
- the readings of a voltmeter and an ammeter in open and closed circuits;
- the spark between the terminal of a Winehurst machine

Psillos *et al.* introduced the 'voltage' concept as a primary one, instead of what was usually done at secondary school through relationships with other circuit variables. They believed that their instructional design was an important step in the development of teaching materials to promote meaningful conceptual learning by the students. Voltage was to be regarded as a property of a battery, i.e. it was to be taught as one variable which describes the state of the battery. This meant that:

- voltage referred to ordered pairs in space, i.e. to battery terminals;
- voltage corresponded to the potential of the battery and not to any action to which it gave rise.

Hendricks (1999) conducted a study on 108 learners (15-16 year olds) in Physical Science randomly selected from 21 schools in the Western Cape. He investigated: their understanding of circuit symbols; distinguishing between a single cell and a battery being a group of cells; distinguishing between the symbolic representations of parallel and series connection of cells; distinguishing between the symbolic representations of parallel and series connection of light bulbs; and features of parallel circuits. His findings indicated that most learners could identify the circuit symbols but that there was confusion between a cell and a battery. The majority of learners could identify correctly light bulbs and cells connected in parallel but 31% of the learners could recall only one feature of parallel circuits, i.e. when two lights are connected in parallel, they operate almost independently of each other. The problem seemed to arise from learners' deficiencies in their prior knowledge.

According to Jaakkola and Nurmi (2004), teaching electricity in Finland had been rare for elementary school learners, and all previous studies had concentrated on 15-year-olds or older. They examined whether a simulation-laboratory-combination with structuring assignments could enhance 10- to 11-year-old Finnish elementary school learners' understanding of electricity and whether it could help them to overcome known difficulties with the subject matter. According to the results of the study, the simulation method was able to improve learners' achievement of learning outcomes compared to the laboratory work method. One explanation for the success of the simulation-laboratory-combination was that simulation possibly helped learners to understand the theoretical principles of electricity by revealing the behaviour of a direct current (DC) circuit and visualising the current flow in the circuit. After understanding the basics of electricity on a theoretical level it may have been easier for a learner to transfer acquired knowledge into the laboratory exercises with real circuits and, as a consequence, acquire a more coherent and holistic comprehension of the topic. Thus the combination of laboratory and simulation work appeared to be able to bridge the gap between theory and reality.

Hence, in terms of the above literature on electricity, the present study identified whether certain misconceptions regarding electricity or lack of prior knowledge regarding the topic exist, or whether there were other factors that could influence learners' performance, through an in depth analysis of the learners' responses to each item on electricity and through interviews conducted with learners and teachers.

(b) Graphs

Graphs are usually used in newspapers and on television as a form of communicating information on the economy, population, pollution and the state of the environment based on sustainability. Consequently the new curriculum has placed emphasis on this important skill, 'interpreting graphs' (DOE, 2002c:14).

According to Hegarty, Carpenter and Just (1991) graphs and diagrams are spatial representations. However, graphs differ from diagrams because they show the relationship between variables, whereas diagrams describe structures and processes (Winn 1987). Bowen and Roth (1998) have argued that learning to use and interpret graphs is an important process skill that scientists have to master because of the vital role that graphs represent in the practice of science. Studies have revealed that students of all ages have difficulty using various representations appropriately, especially graphs (Leinhardt, Zaslavski & Stein 1990; Schnotz 1993). In other studies it was found that some individuals who had already obtained BSc and MSc degrees also demonstrated difficulties when interpreting simple data sets through transformations into graphical representations (Bowen & Roth, 1998; Roth & McGinn, 1997).

Bowen and Roth (1998:86) believed that the correct interpretation of a graph does not lie in understanding the representation itself as a "static object, but rather in understanding the social actions through which the graph was originally constructed". Therefore it is important that learners know how to use graphs to express their own data, instead of just identifying the different axes and variables, i.e. looking for trends and constructing scientific arguments are more important. A similar argument can be made for tables. The general public ought to be capable of interpreting graphs and tables, since they are presented with simple graphs and tables either in the newspaper or in the workplace every day.

Janvier (1978:3.2) described 'graphical interpretation' as a general process which consisted of translating data from one form to another. He also described graphical interpretation as a "progressive integration of the various pieces of information conveyed by the graph with the underlying situational background". Janvier's (1978) findings indicated that there was a definite link between reading and interpretation. He found that inadequate reading skills were responsible for many of the failures in interpreting graphs. Unfortunately the present study does not have sufficient evidence to support the above finding but it would have been an interesting finding.

According to Janvier (1978) and Preece (1985), learners had difficulty in interpreting graphs because of the many forms of representation presented. They believed that the verbal descriptions, formulas and tables provided were often used to represent the same relationship which confused the learner. Their research was supported by Chandler and Sweller (1991:293) who showed that poorly organised data caused learners to divide their attention among the various pieces of data and this created "cognitive load" which, in turn, led to poor processing of information by learners.

Ferry *et al.* (2002:2) outlined the steps studied by researchers with regard to how learners interpret graphs and tables. The processes involved:

> reading a graph or table; deciphering the labels on axes and the headings of columns; describing the global features of the data such as maxima, minima, slope, turning points, regular trends or the means of data presentation such as picture form, bars, columns, lines; relating the properties of the graph and chart to information described in accompanying text; and applying prior knowledge to aid in the comprehension of the information presented.

They identified the skills involved in the above processes as reading, interpreting information and application of knowledge to a different context by inferring.

This difficulty in interpreting points from a graph was also noted in a study by White (2003) who tested the process skills of Grade 10, 11 and 12 teachers from poorly performing public schools in Mamelodi and Atterridgeville, in Gauteng, South Africa. The aim of the study was to test process skills and required no prior knowledge of content. However, it has been argued by Ogunniyi (1999) that it is difficult to set test items that separate process skills and content. White found that most teachers gave the incorrect reading from the line graph but most teachers could interpret bar- and pie-graphs.

Sadeck and Scholtz (2003) carried out a 40-minute pencil and paper test on first, second and third year science teachers, at the Peninsula Technikon in the Western Cape, South Africa. A large proportion of the students (+80%) attended former DET schools. The study targeted process skills such as measurements, tabulating results and graphing. Most students had difficulty reading and inferring information from various types of graphs.

Howie (2001) reported that most Grade 8 South African learners had difficulties with the interpretation of tables and graphic representations. The majority of his sample consisted of high school learners in the Western Cape. A 90- minute pencil and paper test were to be answered which included multiple-choice questions, short-answer questions, extended-answer questions and performance tasks. These questions were designed based on information on the implemented curriculum for all the schools participating in the study.

In conclusion, the achievement of competence in graphical interpretation is a very important process skill that has been emphasised in the new curriculum (DoE, 2002c). The importance of further research on how learners learn from graphs (Winn, 1987) has prompted an investigation on problems related to learners' interpretation of graphs. Hence, this study highlighted the strengths or weaknesses of learners by studying their responses to questions on CTA papers, so that teachers may be made aware of them. The study revealed whether there were any shortcomings in the mode of representation of the particular CTA graphs and whether these representations affected the learners' response to the questions, or whether it was a poorly under-developed skill that needed to be dealt with by proper teaching. In the present study, in-depth interviews with Grade 9 learners also helped to account for some problems that learners experienced with the interpretation of graphs, with particular emphasis on performance skills.

(c) Imagery in chemistry

Wu, Krajcik and Soloway (2001) found that many students had difficulty learning and understanding symbolic and molecular representations of chemistry. In their study at the University of Michigan, they investigated how eleventh graders developed an understanding of chemical representations with the aid of a computer-based visualizing tool. The results showed that students' understanding of chemical representations improved substantially.

Three levels of representations in chemistry have been identified by researchers. These are the *macroscopic, microscopic* and *symbolic levels* (Gabel, 1998 and Johnstone, 1993). Wu, Krajcick and Soloway (2001) mentioned that chemical processes are observable; at the macroscopic level, for example, burning candles. At the microscopic level chemical phenomena are explained by the arrangement and motion of molecules, atoms or sub-atomic particles. Chemistry at the symbolic level is represented by symbols, numbers, formulas, equations and structures. In several studies, many students were reported as tending to remain at the sensory level and were unable to visualize and interpret molecular and symbolic representations (e.g. Ben-Zvi, Eylon & Silberstein, 1986; Gabel, Samuel & Huhn, 1987; Rochford, Fairall, Irving & Hurly, 1989).

Kozma and Russel (1997) argued that if students understood representations, they would be able to generate interpretations, make translations and manipulate those representations. According to Mammino (2002), an understanding of chemistry involves a combination of the macroscopic and microscopic level of the observed phenomena and the microscopic level of atoms and molecules. At present the new Grade 11 Physical Science curriculum has included macroscopic and microscopic levels of chemistry as part of the content that learners need to know. The familiarization with the objects and events at the microscopic level is essential to the understanding of chemistry. Mammino believed that visualization through imagery was a powerful tool to facilitate such familiarization.

Mammino's (2002) study on the use of imagery by students taking general and physical chemistry courses at the University of Venda revealed problems with visualisation and imagery. Learners were not familiar with the teaching activities that involved imagery and had difficulty in interpreting it.

Hence, from the literature on using imagery in chemistry teaching, it appears that imagery can be a useful and powerful tool for enhancing an understanding of chemical reactions at a microscopic level. However, studies have revealed that at least some students were not very familiar with the use of imagery in chemistry.

The present study of CTAs therefore set out to make some inferences pertaining to learners' misconceptions of selected chemical formulae and to discuss the suitability of using imagery in the context of assessing by teaching one aspect of chemistry.

The above studies in the literature focused on students at tertiary level and Grade 11. This study has used CTAs to investigate how learners from a lower grade, who are much younger, performed in using imagery. It was interesting to see whether or not the use of imagery improved the learners' understanding of chemical formulae at the Grade 9 level compared to the studies done in tertiary institutions and at a higher grade level.

(d) Interpretation of text and diagrams

Today it is very important for learners to be able to read critically and to use problem solving skills, as emphasized in the new curriculum (DoE, 2002c). This view seemed to have been supported by Koch (1995). He also stated that "the development of comprehension skills is particularly important today in a period of accelerating technological change" (Koch, 1995:613).

Research has been carried out to the development of reading strategies (e.g. Condy, 2006; Paris, Wasik & Turner 1991, cited in Koch, 1995). Some of the purposes of these instructional strategies, based on reading comprehension, are the following: "to identify main ideas, to make inferences, to inspect the text, to review and reflect, and to follow other metacognitive strategies" (Koch, 1995:613). It was found that successful readers of scientific texts will use strategies such as skimming and examining pictures, graphs and captions, then move back and forth in the text. To read a text critically, one must have the necessary skills which include: reading all the sentences in a passage without skipping; the ability to analyse a passage by breaking it up into small segments, and the ability to summarise what has been inferred from the text (Koch, 1995).

According to Hegarty, Carpenter and Just (1991:666), "diagrams are a suitable means for conveying scientific information". To facilitate learners' ability to grasp certain scientific facts, a visual representation or text presented to learners would make it easier for them to grasp the scientific argument or facts. Certain scientists have believed that visual and spatial representations are important tools to use (Ferguson, 1977; Shepard, 1978 & Smith, 1964). Literature reviewed in Hegarty *et al.* (1991) and Duchastel (1983) suggested that the inclusion of diagrams could be effective in instruction when they provided the reader with spatial representations that were often difficult to derive from text. However, they also mentioned that this depended on the skills of the reader to be able to extract the relevant information from the diagram.

One study found only a very low correlation obtained between scores for reading comprehension and problem-solving scores and concluded that these two skills might be independent and should be investigated further (Koch, 1995). Koch argued that the development of these two skills should receive independent treatment and that teaching problem skills alone will not necessarily improve reading comprehension skills.

In conclusion, after a preliminary study of the nature of the 2004 CTA instrument used in the present investigation, a literature review on the concepts and certain skills with which learners seemed to have problems assisted the writer in developing a research sub-question based on misconceptions and misinterpretations. It was decided to seek additional insights into possible local factors that might either support these earlier findings or contradict them. Although the identification of misconceptions is not the main issue in this study, it was deemed necessary to include them for awareness purposes so that teachers could be informed of some of the basic problems their own learners encountered and which affected their performances here in the Western Cape.

(e) Language, technical terminology and performance on science tests

Various research studies have revealed that language has played a vital part in learners' performances. Learners who were taught in their mother tongue performed better than learners who used English as their second language. Hence, it is the intention of the present study to investigate this aspect of the CTA as well.

Howie (2001:27) reported that only 26% of learners spoke the language of the TIMSS test as their first language and these performed better in both mathematics and science. The South African National Study in mathematics and science showed that learners who took the test in Afrikaans scored higher than learners who took the test in English (Reddy, 2006b). According to (2006b) language proficiency featured as a contributory factor to South Africa's poor and diverse performance.

On a contextual level, according to a South African report by Laugksch, Muller, Abel, Soudien and Favish (2005) home language appeared to have affected learners' success in school mathematics and science.

According to Inal (2002), English second language participants at high schools situated in privileged areas achieved significantly higher scores than those who attended schools situated in underprivileged areas (townships).

From the above research, it seems that the test language and terminology used in testing also impacts on the performance of English second language learners who are taught in English.

2.6.5 Teachers' under-qualification and inexperience

According to Phurutse (2006), after an intensive interview with South African teachers from former DET schools in Johannesburg and Pretoria, it was revealed that the teaching of the lower grades by under qualified teachers and the lack of science and mathematics knowledge were in their view major contributions to poor matriculation results. In other words teachers' qualifications and knowledge of the subject are very important in the lower grades (grade 8 and grade 9). Besides their qualifications and experience, it has been argued that their "voices" were not heard in the interest of education even though they were the closest to the school "milieu". (Nieto, 2003, cited in Phurutse, 2006:214). According to Phurutse (2006), analysis of matriculation results and factors that influence their performance are often provided from a researcher's perspective. Teachers' 'voices' should also be heard to improve academic performance as provided for in this study.

2.6.6 Historically, racially disadvantaged schools

Schools also play a major role in learners' performance. Very few South African schools are producing a high proportion of learners with sufficient marks in mathematics and science for university. According to Reddy, van der Berg; Lebani and Berkowitz (2006) there are many problems in the schooling system that warrant attention. These include the former racial character of the schools which has an influence on learners' performances. For example: African schools have been disadvantaged from the previous racial dispensation and their results are notably weaker in subjects like mathematics and science (Reddy *et al.,* 2006). However, studies have shown that commitment by both teachers and learners has a positive influence on performance (Reddy *et al.,* 2006).

2.6.7 Implications of this overview for the present study - its design and direction

The above literature review identifies possible factors that influence learners' performance. It is quite evident that the socio-economic status of schools, gender, language, ignorance and misconceptions, racially disadvantaged schools, teachers' under-qualifications and inexperience played a significant role in the achievement levels of learners. This prompted a further study on the above factors using the CTA as an instrument for assessing the Grade 9 learners from schools of different social and racial backgrounds. Since the CTAs were compulsory for all Grade 9 learners, the above known factors had to be studied in depth for future recommendations to curriculum planners, teachers and policy makers.

2.7 Common Tasks for Assessment: a recent form of assessment

The notions of the CTAs were introduced in Chapter 1. Its purposes were outlined and its implementation problems discussed.

Like any test, its suitability should be judged using certain criteria. In Australia, the criteria include: knowledge, skills and understanding; demonstration of higher-order thinking skills; emphasis on recall and prior knowledge; degree of ambiguity in test items; any learning styles advantaged; and the level of assessment of learning outcomes (Department of Education and Training: Government of Western Australia, 2000). For this study the ten criteria for evaluating the quality of an achievement test specified by Ebel (1972), together with three additional criteria appearing in DoE (2002c) have been used (see Chapter 4).

Any form of assessment has its limitations and it is therefore difficult to satisfy every learner, teacher or school. Some of these limitations have been identified by Gipps and Stobart (1997) as follows:

- Content tested - the examiner has to decide on which content to test.
- Type of questions - the examiner has to decide on style of questioning.
- Administration and marking – developing reliable tests and a fair assessment criteria.
- Score interpretation – national tests should be used carefully since it only reveals limited information.

Since the CTA is a recent form of assessment, little research has been conducted on its usefulness and effectiveness.

2.7.1 Studies using CTAs in South Africa

During 2002, the History and Geography teachers from two well resourced schools in Grahamstown participated in a trial run of the CTA for the Grade 9 Human and Social Sciences (HSS) Learning Area of C2005 (Wilmot, 2003). While the teachers were generally positive about the new assessment tool (the CTA), they identified a significant disjuncture between the 'rich' knowledge outcomes of national policy documents and the CTA Teacher's Guide on the one hand, and the Section A and B assessment tasks on the other hand. This prompted the writing of a report by Wilmot who provided a detailed evaluation of the CTA for the Human and Social Sciences (HSS) Learning Area which was implemented and trialled at the two schools. The report acknowledged that the CTA, as a new instrument for assessment, was exciting and innovative; but the report also explained a number of problems and issues arising out of the teachers' experiences of implementing the new assessment instrument in the classroom. The teachers who participated in this study reported that they had gained a great deal through reading and attending workshops on the theory which informed change. In addition to studying the national policy documents, the teachers also read articles on a variety of educational topics such as learner-centred education, critical thinking, constructivism and assessment (Wilmot, 2003).

In 2004, Wilmot (2004) analysed the October-November 2003 HSS CTA performances from the same two schools. She stated in her report that there was a pleasing link between the attainments in Section A and Section B and that there was a big improvement in the content and structure of the previous CTA (2002) in terms of the questions asked and the types of learning assessed. The teachers said that they felt they were better prepared for the CTA. The remark, "It has enabled us to develop and think", made by a geography teacher, summed up the value of the CTA as a tool for initiating and supporting the transformation of teaching and learning in South Africa (Wilmot, 2004:81).

No rubrics were used in Section B of the 2003 HSS CTA. Wilmot (2004:83) believed that the shift away from rubrics assumed "a high level of teacher competence and subject knowledge, and the responsible use of professional judgement".

Recently the national Department of Education (DoE) and the Independent Examinations Board (IEB) contracted Khulisa Management Services to conduct a General Education and Training (GET) – Grade 9 curriculum and assessment study to inform decision-making processes related to the General Education and Training Certificate (GETC). The study was carried out from the end of 2003 to 2004 after the first national CTAs were implemented. The overall purpose of the study was to investigate the situation in Grade 9 with particular reference to assessment practices, to inform national policy and to inform preparation for the (GETC); and this was reported in an overview document in the "Research Study on Curriculum and Assessment in the General Education and Training Band – Grade 9" (DoE, 2004b).

The research study reported on a number of areas, but this review of the literature will focus only on the implementation of school based assessment (Continuous Assessment) in Grade 9 and on external assessment (Common Tasks for Assessment) in 2003. A total of 1500 schools were selected by the DoE from nine provinces for the study. Findings from the study reported that:

- Most of the schools completed the CTAs – but there were some responding schools, mainly rural, who stated that they had not completed the CTAs.
- More principals than teachers stated that they were confident to implement the CTAs.

- More than two-thirds of the respondents indicated that moderation of CTAs for all learning areas had taken place.
- Most schools had been supplied with internal marking guidelines but fewer found these to be available and user-friendly.
- Overall, the educators felt that the CTAs were somewhat appropriate in terms of the age of Grade 9 learners.
- Problems that emerged in the data relating to the CTAs were:
    - **many schools indicated that the academic level was too high;**
    - **late arrivals of the documents at the schools occurred;** and
    - there was a lack of sufficient external monitoring of the CTAs. (Emphasis supplied)

The report stated that provincial officials, district officials, teachers and Heads of Departments were positive about the impact of the CTAs on school-based assessment and that they could be used as a model for school-based assessment. However, only a few schools reported that they were able to utilise the CTAs as a model for school-based assessment. Several schools requested more guidance, in the form of training and support, in order to utilise the CTAs as a model for CASS.

The report recommended that:

- **the content and impact of the CTAs be highlighted in terms of their importance for the assessment of Grade 9 learners;**
- the language of the CTAs be made more accessible, i.e. be made more contextualised;
- **the CTAs be delivered earlier to schools to provide more time for moderation of performances in both Sections A and B; and that**
- the absenteeism of learners from schools during the conducting of CTAs be addressed, since educators were confused about what to do when learners had not completed CTAs due to absenteeism.

Assessment tasks are mainly set in a 'real life' context. This context demands language skills since it requires reading skills and interpretation skills. Cooper and Dunne (1998), reported on a study done in the U.K. which examined 10 -11 and 13 -

14 year-old learners on national mathematics assessment tasks. The study revealed that assessment tasks set in 'real life' contexts disadvantaged working class learners. These results were similar to a study done by Bansilal (2008) and Boaler (2003).

Boaler (2003) believed that standardized testing discriminated largely against certain learners at low SES schools and against those learners who never spoke the language of the test.

According to Bansilal there was a mismatch between the intended curriculum and the perceived curriculum. She did a study on the Grade 9 Mathematics CTAs (2004). The CTAs, which was used as a form of assessment, was based on 'real life' situations and therefore a certain context dominated the questions. She argued that the intention of the department of education to create an assessment tasks, with 'real life' contexts that will be fair to all learners from different social backgrounds, has not transpired (Bansilal 2008). She found that learners had problems answering certain questions because the information given was too wordy. As a result learners never fully read the information provided and missed out on crucial information. This study is very useful for the present study since it deals with the same type of instrument, the CTA and contextualised assessment tasks. However the present study identifies the process skills used to deal with problems in a 'real life' situation and an in depth analysis of the learners' performances on the process skills in the Natural Science CTAs will establish whether the above remarks can be supported or not.

2.7.2 Implications of this review of CTA studies for the direction of the present investigation

Any form of educational transformation lends itself to certain problems – either internally or externally. Since this study was about the performance of Grade 9 learners on the Natural Science CTA, the researcher also looked at any possible administration problems that could have developed during its implementation.

In summary, assessment has been highlighted as a crucial tool in education. Recently the CTAs have been introduced as a form of systemic assessment, as described in Chapter 1, and their stated purposes were used as criteria for judging the quality of the instrument used in this study, the CTA test. This section of the literature review has also raised issues of accountability, the use of external assessment and the poor use of formative assessment. Therefore one objective of this study was to reveal whether or not the CTA could be used as a tool to measure the overall performance of learners from different categorised schools. Another objective was to measure the quality of the instrument used and to decide whether the issues of accountability and lack of formative assessment could be answered fairly.

Knowledge of these problems related to the CTAs implementation fostered an outlook for similar problems that could have hampered the performance of learners in 2004. The above studies looked at different learning areas but this present study considered only Natural Science.

2.7 Chapter summary

In this chapter the literature review was presented in three sections. Firstly an overview was given of the issues and debates in the field of academic performance testing and assessment. Secondly, possible factors that have been identified as influencing academic performance have been discussed. Thirdly, an overview of assessment has been given, with emphasis on the CTA - and past problems discussed involving its implementation.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The approach adopted in this study engaged a combination of both quantitative and qualitative research methods, as indicated in Figure 1.1 (Flow diagram) on page 29 of Chapter 1.

In section 3.2 below, a description of Phase I presents the aims, purposes, justification for and outcomes of the small-scale **feasibility study** that was conducted using an *ex post facto* research methodology. This section describes the origin, source, use and composition of the 2004 Natural Science CTA examination paper as a whole, and briefly introduces the process skills and Assessment Standards it contains. The first data-gathering instrument (the second part of the 2004 Grade 9 Natural Science CTA examination, namely, section B) is presented and explained in more detail in terms of its composition, length, content and readability. This includes a more detailed analysis and classification of the process skills, Learning Outcomes and Assessment Standards pertaining to each one of its 25 CTA items in turn.

During the feasibility study trialled in Phase I, the completed CTA examination scripts of twelve classes of learners were obtained from three conveniently available high schools - one of low socio-economic status (SES), one of medium SES and one of high SES. A preliminary analysis was made of the raw scores of 511 Grade 9 learners – leading to the formulation of several recommendations for planning and extending the study to an enlarged Phase II, the **main study** (the findings which are reported subsequently in Chapter 4), involving twelve new high schools. The raw score data generated by the pilot study in Phase I was also used to establish a satisfactory reliability coefficient for Section B of the Grade 9 Natural Science CTA.

In section 3.3, Phase II of the methodology of the main study presents the two focus questions and the seven research sub-questions. It describes the arrangements made for the large-scale collection of quantitative data once again utilising an *ex post facto* research methodology. The selection, size, context and nature of the twelve high schools are described. Next, the data collection procedures for Phase II are described in terms of their ethics, management, permission, sequence and time-table. Then the lists of dependent and independent variables are presented and, finally, the intended data processing procedures and techniques are introduced.

In section 3.4, Phase III of the methodology and procedure introduces the triangulating qualitative data generation strategies. The roles and design of the follow-up interviews and their procedure are outlined in terms of their purposes of data corroboration, explanation, validation, elaboration, elucidation and clarification. The selection of six teachers and 52 learners for the follow-up interviews in 2005 is described, and their contexts are also noted. The second and third data-gathering instruments – namely, the interview schedules (for both learners and teachers) – are explicated, and then the interviewing procedures and precautions are outlined. Phase III ends by describing the synthesised methodological contributions of Phases I, II and III to producing data for a final discussion of various aspects of the validity of the CTA in Chapter 5.

Section 3.5 summarizes the chapter.

3.2 Phase I: The feasibility study

3.2.1 Aims and purposes of the feasibility study, and their justification

The focus of the preliminary feasibility study early in 2005 was on studying the responses of conveniently available classes of learners to the 2004 Grade 9 CTA Natural Science test paper, a copy of which is reproduced in Appendix 1. The learners' performance scores on each of the 25 items were readily at hand for the purposes of the investigation.

In the Phase I pilot study three conveniently accessible schools were randomly selected - one in a high status suburb, one in a middle-class suburb and one in a low SES suburb. When approached, the principals of all three schools willingly loaned their learners' scored CTA examination scripts to the writer (the researcher) for preliminary analysis.

The aim and purposes of the feasibility study were to:-

1. detect whether the two-hours-long CTA test paper as a whole might be interpreted by educators as too easy, too hard, or at a reasonable level of difficulty;
2. calculate a preliminary reliability coefficient for the CTA (using the learners' performance scores from the three schools) to determine whether it was sufficiently high to justify its use in the continuation of the research;
3. gauge whether there might be a possible association of ranked SES levels with overall levels of performance among the three schools;
4. find out whether the CTA scripts were readily accessible from various schools and whether teachers and learners were accessible for possible follow-up interviews when required;
5. rehearse and establish an efficient procedure for entering the data on Excel sheets for ease of analysis;
6. develop a formal procedure for securing permission from the Department of Education and from school principals;
7. anticipate problems that might develop during an extended collection of the CTA data and the recording of marks from more schools (for example, the possibility of some learners' scores being missing; or the chances of incorrect score totalling within the schools; etc.);
8. rehearse the feasibility of using appropriate statistical methods on items' scores (e.g. means, standard deviations, tests for normality, correlations, exploratory factor analyses and the correct selection of either parametric or non-parametric statistical tests);
9. establish and define several possible pertinent dependent and independent variables (such as SES and gender);
10. detect whether there were statistically significant differences in performance between the three schools of different socio-economic status (SES) on selected CTA items of interest, to direct further possible research in an enlarged analysis with more schools in Phase II.

3.2.2 Origin, source and use of the instrument

The grade 9 CTAs (Common Tasks for Assessment) were introduced and piloted by the Western Cape Education Department in six different learning areas in a few schools in 2003. The prescribed CTA examination was set externally but marked internally in 503 schools in the Western Cape in 2004. It served as a common moderating tool for CASS

(Continuous Assessment) across schools, and learners were allowed two hours to complete it.

Continuous Assessment is school-based and, at present, it constitutes 75% of the total assessment of a Grade 9 learner. All learning areas, including the science CTA, have two components. In the first component, learning, teaching and assessment activities are created for learners to demonstrate their achievement of a variety of skills, knowledge, attitudes and values (SKAV). For example, the first component of a CTA – Section A – might specify that a **group** practical investigation be carried out in class through co-operative learning. However, in Section B of the CTA, each learner would be obliged to perform this second component **individually** instead (DoE, 2002b). Each task in Section A and Section B was contextually designed. This meant that "links are made right at the start of the topic, and used as a starting point to introduce and develop scientific ideas" (Bennett, 2003:102).

3.2.3 Process skills and Assessment Standards in the 2004 CTA Science instrument, and its readability

The Grade 9 Natural Science CTA Sections A and B (Appendix 1) contained questions involving certain process skills. Classified by a panel of four collegial specialists in Natural Science and a subject advisor, and expanded in more detail in Appendix 2, the seventeen process skills (DoE, 2002c) that were evident in the 2004 science CTA were mainly the following:

- Inferring
- Interpreting information
- Communicating science information
- Planning science investigations
- Identifying variables
- Recording information
- Decision making
- Problem solving
- Drawing a conclusion
- Recalling meaningful information
- Observing and comparing
- Sorting information

- Hypothesizing (inferred)
- Evaluate information
- Raising question about a situation
- Applying knowledge
- Justifying an argument (scientific reasoning)

Appendix 2 also records the various agreed RNCS Assessment Standards associated with items 1.1 to 5. The acceptable minimum score was decided upon by the panel of experienced teachers, after consensus was reached. According to Siebörger (2004:39), "assessments of outcomes in practice will need to be flexible", and educators should discuss with other "teachers or assessors" what can be regarded as acceptable to achieve the outcome. This was done, based on the percentage of learners who reached the achievement level.

A readability index was calculated on three paragraphs in the Natural Science CTA using the Flesch's formula nomogram (Harrison, 1980: 77-78). This showed a reading ease score of 74, which implied that the 2004 CTA test was close to being fairly easy to read at the 15-year-old level.

The degree of competence levels were identified by using Green and Naidoo's (2006) framework. This was established by classifying the different process skills under each level of cognitive competence (see chapter 2, page 40). This was done to establish the level of the tasks presented in the Natural Science CTA.

3.2.4 Data collection procedure for Phase I

The pilot study research design entailed an *ex post facto* approach; in other words, the raw data were already available for a quantitative analysis, which included preliminary stages of refinement, systematisation and purification. According to Kerlinger (1986) an *ex post facto* research methodology is one in which the independent variable or variables have already occurred and in which the researcher starts with the observation of a dependent variable or variables.

Early in 2005, the pilot data collection procedure for Phase I was as follows:

- Permission was granted by the Department of Education to conduct the necessary research. Appendix 8 contains a copy of the letter of permission.

- Preliminary meetings were arranged separately with the three principals to discuss what the research entailed.
- A qualitative aspect of the data production entailed rehearsals of interviewing teachers and curriculum planners telephonically and face-to-face using a tape recorder.
- Data were collected from the three pilot schools, involving 51 Grade 9 Science learners, during February 2005.
- The item scores from each individual CTA, supplied by the schools, were captured in Microsoft Office Excel and then exported to Statistica early in March, 2005.

Finally, the items were provisionally classified taxonomically by the writer, with assistance, utilising the RNCS (DoE, 2002c) categories, with specific reference to process skills and Learning Outcomes (see Appendix 2).

3.2.5 The pilot school samples A, B and C

(a) Selection procedure

Three schools were chosen purposefully to represent the different levels of SES as defined on page 27 of Chapter 1. To preserve their anonymity and to prevent their recognition or identification, they are described below in broad detail only. Former House of Assembly schools are designated HOA; former House of Representatives schools are designated HOR; former Department of Education and Training schools are designated as DET.

(b) The samples and their contexts

Sample A was a very well resourced school with learners coming mainly from middle to affluent class backgrounds. School A's sample consisted of approximately 150 Grade 9 learners in a high SES school in the Western Cape. It was a former HOA school. This was an all-girls school with English as the predominant first language. Only 3% of the learners spoke Xhosa as their first language with English as their second language. The annual school fee levy was in the range R10 000 to R12 000.

Sample B consisted of learners mainly from working class to middle class backgrounds. School B's sample comprised 121 Grade 9 learners in a medium SES school in the Western Cape. It was a former HOR school. 52% of the learners were female and 48% were male. Only 2% spoke Xhosa as their first language, with English as a second language. The annual school fee levy was in the range R900 to R1500.

Sample C consisted of learners from a working class background. School C's sample comprised 240 learners in a low SES school in the Western Cape. It was a former HOR school. 52% of the learners were female and 48% were male. 14% spoke Xhosa as their first language, 52% spoke English as their first language and 34% spoke Afrikaans as their first language. The annual school fee levy was in the range R400 to R600.

3.2.6 Outcomes of the feasibility study

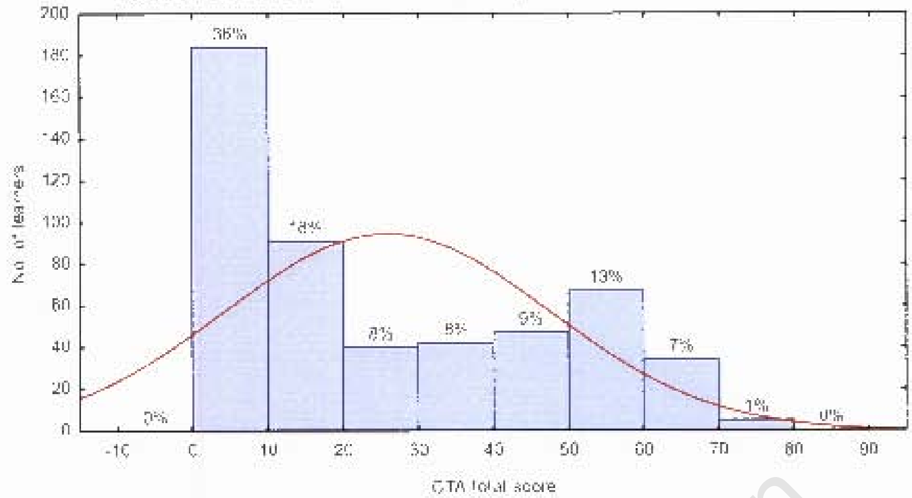
(a) Most of the scripts proved to be readily accessible from the schools.

(b) Problems arising during the collection of the CTA were noted. For example: it was discovered that procedurally one should first speak directly to the principal, and only then to the Natural Science teacher instead of to the head of department who did not necessarily know where the learners' CTA examination scripts had been stored.

(c) Data for computing were entered efficiently by itemising each CTA question. Data capture was conducted either in adult pairs – where one person read out the marks and the other recorded the marks on the computer – or data were entered by the researcher alone.

(d) Figure 3.1 presents the distribution of the raw scores for the 511 Grade 9 learners from the three pilot study schools, A, B and C taken as a whole, for their performance totals on Section B of the 2004 Grade 9 CTA. The scores were highly skewed and ranged from 1 to 73 marks out of 80, with a mean score of 28.8. The percentages on the top of each column designate the percentage of the whole sample that scored in the specified 10-mark range; e.g. 18% of the learners scored between 10 and 19 marks.

Figure 3.1 Distribution of CTA total scores for 3 pilot schools A, B and C combined



From the results of the pilot study (mean score of only 36%), it appeared that the CTA test paper may have been too hard for the majority of learners sampled in Phase I.

(e) For the 511 learners, the computed Cronbach alpha reliability coefficient of the CTA in the pilot study (Phase I) was found to be $\alpha = 0.94$. This was a very acceptable value and indicated that the intended investigation could continue as planned with an enlarged sample of schools in Phase II, the main study.

(f) Table 3.1 presents a comparison of the performance score totals of the samples of learners in the three schools A, B and C on the Natural Science CTA test.

Table 3.1: A comparison of the sampled Natural Science CTA performance score totals of the high SES school, the medium SES school and the low SES school in the pilot study

School	SES	Sample size (convenient)	Mean ± SD (out of 80)	Mean score (%)
A	High	150	54.4 ± 10.2	68.0%
B	Medium	121	34.3 ± 12.6	43.0%
C	Low	240	10.0 ± 6.6	13.0%

The findings reported in Table 3.1 suggested that the 2004 science CTA may have been too easy for the Grade 9 learners in school A. Furthermore, it seemed that level of SES or geographical location was related to the performance levels in the samples taken from the three schools. The higher the SES of the school, the better was the mean score, although the sampling was convenient, rather than purely random.

(g) The **independent** variables identified for investigation in Phase II were then selected as: *learner's home language, name of learner's school, gender* and *SES* (as determined by school fee level). The identified **dependent** variables selected were the *learners' separate scores for all 25 items* individually in the CTA, and *the learners' CTA test score totals* out of 80.

(h) Appendix 3 records the 511 learners' mean scores for each item. Learners scored particularly low marks for certain items compared to others, notably items 2.1, 2.5, 2.6 and 2.7. The whole of question 2 was an investigatory question on the topic of 'variables'. The mean scores recorded for performances on item 2.1 were generally very low across the three schools. Despite the information given, the learners could not identify the correct variable, i.e. the thickness of the pencil lead. The overall response to item 2.5, which related to variable identification by the learners, was also inadequate.

(i) According to the mean values, the learners in schools A and B performed well in 'interpreting information' for the following items: 4.2 (b)1, 4.2 (b)2 and 4.2 (b)3 on chemical formulae (see Appendix 4). However, the mean scores for these items in school C (low SES) were very low (with values of 0.25, 0.10 and 0.02 respectively) compared to the scores in the other schools. In these particular items, three straight line graphs were given and questions were broken down. This finding possibly implied: either those learners from the other two schools (high SES and low to medium SES) had spent a lot of time previously working through these types of problems, or that the CTA problem itself had not been sufficiently clearly stated.

Appendix 4 presents an exploratory factor analysis of the 25 items using the scores from the three schools A, B and C. There was a preliminary indication that the structure of CTA may have contained four discernable components accounting for perhaps 73% of the total variance in the scores, which was a very promising finding, although tentative on account of the relatively small sample size in the pilot study.

(j) Extended permission was granted from the head of the Western Cape Education Department (WCED) who was favourably disposed to enlarging and widening the study. Subsequently, appointments were set up to meet with ten more principals to ask permission to use the learners' CTA examination scripts.

3.2.7 Recommendations emerging from the pilot study (Phase I), for the subsequent planning and design of the main study (Phase II), were as follows:-

- The number of schools involved could now be expanded from three to twelve (with three schools to be purposefully selected in each of four levels of defined SES: high, medium, medium-low and low respectively).
- At each school the CTA examination scripts would be sought from a person who was involved with the teaching of Natural Science, instead of "just anyone". This should speed up the process of collection. The pilot study experience had suggested that people approached also tended to develop an interest in the outcomes of this study. This was pertinent for arranging follow-up interviews about the CTA with teachers and learners.
- It would be pertinent to remind the designated teacher to collect the CTAs, by repeated telephoning if necessary.
- It would be important to seek permission from teachers and principals for CTAs to be borrowed for a reasonable period of time, since entering the large amount of data would be time-consuming. If scripts were required to be returned to schools as soon as possible, it would be important to do so.
- Also it would be important to enquire about the total number of Grade 9 learners who wrote the CTAs and whether the CTAs given would be a reasonably representative sample of learners; for example, some samples of learners available might not necessarily be graded according to past academic achievement.
- A thank-you note would be written to the principal and teacher after collecting the CTAs, since finding scattered and discarded CTAs in the store rooms in schools could be a tedious task itself.

Overall, the pilot study worked well, with no serious complications.

3.3 Phase II: The large scale quantitative study

3.3.1 The research questions

1. How did a sample of 1572 learners and their teachers experience the 2004 Grade 9 Natural Science Common Tasks for Assessment (CTA), Section B, as a potential instrument of performance and educational achievement?
2. Why did the learners perform in the ways that they did, and what deeper insights into the learners' achievements on the CTA were gained when their responses were analyzed?

In order to probe the two focus research questions, the study considered seven dimensions: learner performance, learners' misconceptions, SES, the quality of the CTA as a test, gender, home language and the interaction between gender and home language. These generated several sub-questions, as follows:-

Sub-question no.1 - Learner performance

On which of the 25 items in Section B of the 2004 Grade 9 CTA in Natural Science did the mean scores for the combined sample of 1572 learners from 12 schools, taken as a whole, meet or exceed the specified minima for acceptable levels of performance?

Sub-question no.2 - Learners' misconceptions

Were the learners' misconceptions in knowledge and skills found to be similar to those already known in the published literature; and did there appear to be any misinterpretations of certain questions when representative samples of English-speaking, Afrikaans-speaking and Xhosa-speaking learners had their CTA answers scrutinized in depth through interviews with teachers and learners, as well as their scripts?

Sub-question no.3a - The quality of the CTA

Did the in-depth interviews conducted with the selected teachers and learners reveal possible short-comings in the wording and composition of each one of the items 1 to 5 (e.g. in respect to clarity, length, layout, degree of abstraction, sequencing, weighting, appropriateness for RNCS 2002, ambiguity and diagrammatic representation?)

Sub-question no.3b - The quality of the CTA

Did the in-depth interviews produce triangulating evidence that clearly illuminated, explained, corroborated or amplified the empirical findings presented as answers to the research sub-questions 1 and 2?

Sub-question no.3c – The content of the CTA

To what extent did the CTA cover process skills, Learning Outcomes and Assessment Standards?

Sub-question no.4a – Socio economic status considerations

When the 12 sampled schools were grouped into four bands according to SES (three highest SES, three second-highest SES, three third highest SES and three lowest SES), did the levels of the 12 CTA average scores (totalled out of 80) correspond uniquely with each of the four bands?

Sub-question no.4b - Socio economic status considerations

Were there significant differences between the mean total CTA science scores of the four bands of 12 schools grouped according to their SES?

Sub-question no.4c - Socio economic status considerations

Did the high level SES schools perform better than the lower level SES schools on all 25 items in section B of the 2004 CTA examination in Natural Science?

Sub-question no.5a - Gender considerations

Was there a significant difference between the total achievement score totals of the 912 females and the 660 males on the 2004 Grade 9 Natural Science CTA?

Sub-question no.5b - Gender considerations

Were there significant differences between the achievement scores of the 912 females and the 660 males on each one of the 25 items of the Grade 9 Natural Science 2004 CTA?

Sub-question no.6a - Home language considerations

Were there significant differences among the total achievement scores of the Grade 9 Natural Science CTA between Xhosa -, Afrikaans - and English-speaking learners?

Sub-question no.6b - Home language considerations

Were there significant differences in academic achievement among Xhosa - , Afrikaans - and English – speaking learners on each one of the 25 individual items of the Grade 9 Natural Science 2004?

Sub-question no.6c - Home language considerations

Were there significant differences among Xhosa- , Afrikaans- and English-speaking learners on the total mean CTA score when sub-grouped according to their SES?

Sub-question no.7a - Gender, home and language interactive effects

Were there significant differences between males and females on the total achievement scores of the Grade 9 Natural Science CTA 2004 when sub-grouped according to language?

Sub-question no.7b - Gender, home and language interactive effects

Were there significant differences between males and females on each one of the 25 individual items of the Grade 9 Natural Science CTA 2004 when sub-grouped according to language?

3.3.2 The samples

(a) Selection

Purposive sampling was implemented to include learners at all levels of socio-economic status, as recorded in Table 3.2. In purposive stratified sampling the researcher chose the sample to be included in the study to suit and satisfy the specific needs of the researcher (Cohen, Manion & Morrison, 2003). In order to group the schools appropriately, school fee levels were selected as the criterion (Fiske & Ladd, 2004). Some earlier studies in the UK, USA, Australia and RSA had shown that student achievement varied with the social types of school attended, i.e. their SES (e.g. Ainley, Graetz, Long & Batten,1995; Ekstrom, Goertz, Pollack & Rock, 1986, cited in Attwood; Riddell & Nyagura, 1991 and Rothman, 1997).

Each of the twelve selected Western Cape schools was grouped within one of the four SES bands (ranging from low fees to high fees). I divided the schools in this manner, based on the school fees and my assumption that the main reason for the majority of learners attending the school was because of affordability purposes as reasoned by Fiske and Ladd (2004). Parents who send their children to a particular school are able to afford it. However, schools situated in a high status suburb are attended by "middle-income learners", whose parents can afford the school fees or "lower-income learners" who are either exempted from school fees or pay partial school fees. (Fiske & Ladd, 2004:71). Table 3.2 summarizes a description of the twelve samples of schools and their learners in terms of several of the selected parameters (including three of the four independent variables).

Table 3.2 The 12 Western Cape schools selected for the main study, grouped according to socio-economic status, background and school fee levels

School code name	SES level	Annual school fee (Rands)	Gender composition of learners who wrote the CTAs		Number of learners tested in Grade 9 (and the proportion used for statistical analysis expressed as a percentage)
			Female	Male	
BLUE	1	R10 000-R15 000	0	51	124 (41%)
RED	1	R10 000-R15 000	150	0	156 (96%)
PINK	1	R10 000-R15 000	178	0	178 (93%)
PLUM	2	R7 000-R9 000	76	53	198 (65%)
GRAPE	2	R7 000-R9 000	50	48	139 (84%)
APPLE	2	R7 000-R9 000	126	104	341 (82%)
BETA	3	R4 000-R6 000	53	48	138 (73%)
ALPHA	3	R4 000-R6 000	40	32	87 (82%)
GAMMA	3	R4 000-R6 000	74	78	226 (67%)
MARS	4	R0-R1 000	36	64	210 (48%)
VENUS	4	R0-R1 000	66	56	122 (49%)
Neptune	4	R0-R1 000	114	126	240 (100%)

(b) Description and contexts

First level SES schools

School Blue was a former "white" school (model C school) situated in a "high status suburb" in the Western Cape. English was the predominant first language. It was a well established boys' school. The majority of learners came from middle class or affluent backgrounds. The school had a capacity of 700-750 learners and 50 teachers. The teacher:pupil ratio was 1:30 in Grade 9. Most Grade 9 learners completed matriculation (Grade 12) so there was no 'drop-out' problem. Of the 51 learners who wrote the CTAs, only 3% spoke Xhosa as their home language, with English as a second language.

School Red was a well established girls' school in the Western Cape and was a former "white" school (model C school) that belonged to the former House of Assembly. . The majority of learners came from middle class or affluent backgrounds. The school had a capacity of 700-750 learners and there were the equivalent of 55 teachers. The teacher: pupil ratio was 1:30 in Grade 9. Of the 150 learners who wrote the CTAs, only 3% spoke Xhosa as their first language with English as a second language.

School Pink was a girls'only school that belonged to the former House of Assembly. The total number of learners in the school was of the order of 800-900 and there were 59 teachers. The majority of learners came from middle class or affluent backgrounds. The teacher:pupil ratio was 1:25 in Grade 9. Of the 178 learners who wrote the CTA, only 3% spoke Xhosa as their first language with English as a second language. The majority of the learners completed matriculation.

Second level SES schools

Schools Plum, Grape and Apple were all former House of Assembly schools in the Western Cape. The majority of learners came from middle class backgrounds.

School Plum had a capacity of 1100-1200 learners of whom approximately 600 were girls and approximately 500 boys. The teaching staff consisted of 72 teachers, and the teacher-pupil ratio was 1:36 in Grade 9. It was an English medium school. Two percent of learners spoke Xhosa as their home language, and the rest spoke English. Of the sample of 129 learners who wrote the CTA, none spoke Xhosa as their first language.

School Grape had a capacity of 550-600 learners with equal proportions of boys and girls. There were 30 teachers, and the teacher:pupil ratio was 1:35 in Grade 9. The majority of learners spoke English as their home language; 5% spoke Afrikaans and 3% spoke Xhosa. About 80% of Grade 9 learners reached matriculation.

School Apple had a capacity of 1300-1400 learners of whom approximately 540 were girls and 800 boys. There were 36 teachers and the teacher: pupil ratio was 1:35 in Grade 9. It was an English-medium school with the majority of learners English-speaking.

Third level SES schools

Schools Alpha, Beta and Gamma were all former House of Assembly schools in the Western Cape. The learners who attended these schools came from working class backgrounds.

School Alpha was an Afrikaans medium school in the Western Cape with a capacity of 300-400 learners. There were 19 teachers and the teacher:pupil ratio in Grade 9 was 1:30. A high percentage of learners who were in Grade 9 reached matriculation.

School Beta was an English-medium school with the majority of learners using English as their home language. The school capacity was 600-700 learners of whom approximately 400 were girls and approximately 270 boys. There were 32 teachers and the teacher: pupil ratio in Grade 9 was 1:37. However, it varied per subject and grade.

School Gamma was an Afrikaans-medium school with a capacity of 1000-1500 learners of whom approximately 650 were girls and approximately 550 boys. There were 54 teachers and the teacher: pupil ratio in Grade 9 was 1:35. About 85% of learners who were in Grade 9 matriculated.

Fourth level SES schools

School Mars was a former Department of Education and Training (DET) school in the Western Cape with a capacity of 1400-1500 learners of whom 900 were girls and 550 boys. There were 45 teachers and the teacher:pupil ratio in Grade 9 was 1:40. All the learners spoke Xhosa as their home language. Only 60% of Grade 9 learners reached

Grade 12. The school was situated in a working class area and the learners who attended the school were all from working class homes.

School Venus was a former House of Representatives school. This school had a capacity of approximately 650 learners with boys and girls in approximately equal proportions. There were 28 teachers and the teacher:pupil ratio in Grade 9 was 1:50. Most of the learners (64%) spoke Xhosa as their home language; 15% used Afrikaans and the rest spoke English. According to a teacher who had been teaching at the school for a long time, only about 50% of the learners in Grade 8 reached matriculation. The rest either took longer, after failing a grade or two, or left to attend other schools. Although the school was situated in a working class area, the learners who attended the school were all from working class homes.

School Neptune was also a former House of Representative school in the Western Cape. It had a capacity of 900-1000 learners with more than 500 boys and 400 girls. There were 30 teachers and the teacher:pupil ratio in Grade 9 was 1:45. 55% of the learners spoke English as their first language, 40% spoke Afrikaans and 5% spoke Xhosa. According to a teacher who had been teaching at the school for a long time, only about 50% of the learners in Grade 8 reached matriculation. The school was situated in a working class area and the learners who attended the school were all from working class homes.

3.3.3 Data collection procedures

An appointment was set up to meet each principal. A letter of permission from the head of the WCED and a letter drafted by myself, explaining my research study and its value, were handed to the school's secretary. Once permission had been granted by the principal, the teacher who was involved with the Natural Science CTA assessment collected the CTA examination scripts from several classes, and either the secretary or the teacher telephoned me to collect the CTAs. Each letter was signed by the principal to ensure that permission had been granted. Confidentiality with respect to the school and learners' names was discussed with either the principal or the teacher concerned.

The CTAs from the different schools were collected from mid-April to the end of June 2005. Each school suggested that a period of about a week be allowed for them to locate and collect all the CTAs. During the interim period telephone calls were made to the various schools' secretaries to remind the teachers about locating and retrieving the CTA examination scripts.

3.3.4 Selection of dependent and independent variables

For the quantitative study the independent variables selected to be investigated were the learners' *home language, gender* and *SES* of the school. The dependent variables were the learners' scores for all *CTA 25 items* taken separately and the learners' *CTA test score totals* as a whole.

3.3.5 Treatment of the quantitative data

The marks allocated to each CTA task varied from item to item, as recorded in Appendix 5, and the whole test totalled 80 points.

The software package Statistica was selected to perform the statistical analyses. The spreadsheets were prepared by naming each column according to **gender, home language, SES** of the school, **item number** and **total score**. The scores generated by each correctly marked item were entered into the computer by the researcher. The methods of analysis involved calculations of means, standard deviations, tests for normality, the correct selection of either parametric or non-parametric tests, correlations and factor analysis.

3.4 Phase III: Production of the qualitative data

3.4.1 The interviews with the learners and the teachers

(a) Purpose

The purpose of the interviews was to obtain data to judiciously corroborate, explain, elucidate or modify, with *caveats*, the main findings emerging from Phase II, in a process of methodological triangulation. Details of the interview schedules are given and explained below in sections (g) and (i).

(b) Procedure

Focused interviews were conducted with groups of purposefully selected learners. Each group of Grade 10 interviewees contained learners with representative patterns of characteristics, i.e. each interviewed group included a combination of learners who scored either a low, medium or high percentage total for their CTA. A focused interview research strategy was appropriate for the study at this point since it concentrated on learners' responses to certain CTA questions which were written by the particular learners themselves in 2004 and subsequently analyzed prior to the interviews.

(b) Focused interviews

In a focused interview, all the people interviewed have been involved in the same situation. In this instance, all of them wrote the CTA in 2004. Another feature of this particular interview is that the researcher has a basic idea of what to focus on during the interview since the researcher has had an opportunity to identify certain elements during the pilot study (Merton & Kendall, 1946, cited in Cohen, Manion & Morrison, 2000).

For example, if – in the current study – learners under-performed appreciably on the CTA items when required to interpret graphs, compared to their better performances on other CTA items, then this finding was raised for discussion in the interviews.

In the present study the researcher selected and based the interview questions on the on-going analysis and findings of the existing, most recent data. For example, a decision was taken to interview learners on Question 2, since most learners across schools had performed so poorly on this question. The actual interviews also concentrated on the subjective experiences of the people who had been exposed to the educational CTA situation. Their responses enabled the researcher not only to test the validity of the hypotheses but also to ascertain unanticipated responses to the CTA test situation, thus possibly generating additional hypotheses before the end of the study.

Data obtained from an interview might substantiate or refute a previously formulated hypothesis (Cohen, Manion & Morrison, 2000). Merton and Kendal (1946), cited in

Cohen, Manion and Morrison, (2000:290), explained the advantages of the focused interview as follows:

> Fore-knowledge of the situation obviously reduces the task confronting the investigator, since the interview need not be devoted to discovering the objective nature of the situation. Equipped in advance with a content analysis, the interviewer can readily distinguish the objective facts of the case from the subjective definitions of the situation. He [*sic*] thus becomes alert to the entire field of 'selective response'. When the interviewer, through his familiarity with the objective situation, is able to recognise symbolic or functional silences, 'distortions' avoidances or blockings, he is more prepared to explore their implications.

Triangulation is defined as "the process of checking the findings from one source of data with those from another" (Vulliamy, Lewin & Stevens, 1990:106). Thus the interviews conducted helped to 'triangulate' the data obtained from the previous CTA analysis.

(d) Selection of learners for interviews

Grade 10 learners were selected for interviewing because they had already written the prescribed CTA the previous year. Purposive stratified sampling was used in order to select learners from six different schools. Based on their performances in the CTA, the names of learners were suggested by the researcher to the teacher. Since the researcher had possession of the learners' scripts, it gave her freedom to consult with class teachers and select a group of twelve to fifteen learners from each school. These were re-grouped further, in the analysis stage, according to their overall score in the CTA. They were divided (on paper) according to low, medium and high achievers, i.e. the teacher chose two or three learners from each group who expressed willingness to be interviewed in either English or Afrikaans. Learners were chosen in this way in order to get a good spread of achievement levels.

(e) Construction of the interview schedule for learners

A tentative interview schedule was designed, based on the earlier data analysis of the learners' performances on items in the CTA in Phase I. As explained in section (f) below, it consisted of six main or leading questions accompanied by follow-up or probing questions (see Table 3.3). The interview questions were linked directly to certain CTA items which learners had difficulty in answering, which had been determined from low mean scores. Having drafted the questions, the proposed schedule was given to two experienced qualitative researchers to face-validate (Khanyane, 2002). The face validation was performed to ensure that:

- the questions asked were clear, simple and straightforward to accommodate for English second-language learners;
- learners would have little difficulty understanding what was being asked;
- the questions were not ambiguously phrased; and
- the questions were designed to meet the research objectives.

(f) Piloting the interview schedule for learners

According to Verma and Mallick (1999), a pilot study can be helpful when researchers are inexperienced in administering research techniques. However, as an experienced teacher, I, the researcher, had developed many of the necessary questioning skills like insightful probing and allowing learners enough time to answer the questions without any interjection. I also had the opportunity to interview learners during the previous year in one of my BEd (Honours) courses and this experience and practice assisted me in avoiding certain pitfalls associated with conducting interviews; e.g. "leading the witness" (Nkopodi & Rutherford, 1994:300).

For my preliminary pilot study of the proposed schedule of questions, six Grade 10 learners who had written the CTA were interviewed solo and tape-recorded. I chose a school where learners spoke English as a second language so that it would be easier to detect and simplify any awkwardly worded questions. My supervisor was present during some of the earlier interviews so that suggestions could be given after the interview. Because the learners in the first set of interviews were Xhosa-speaking, their normal classroom science teacher suggested that she be present as well during each interview in case her assistance was required to translate questions to any one learner who was not clear. The interviews took approximately 15-20 minutes each, and they were conducted in a specially arranged office in which learners were made to feel comfortable and relaxed. The following methodological procedures were incorporated into the interviews:

- The pre-determined questions were asked exactly as they were written. Altering questions might have changed the intended meaning and therefore might have failed to elicit the required information. This was explained to the school's science teacher present.

- If the learner's response was not clear, probing was done by me, the interviewer, for explanation and clarification. Trochim (1999:130) suggested that the most effective way to encourage someone to elaborate is to pause and wait, and this he refers to as the "silent probe". It suggests that the interviewer is waiting and listening for what they will say next.
- I made an attempt not to finish questions for the respondent, as this could "lead" the interviewee, hence affecting the response.

After completion of the pilot study, comments were made by my supervisor on the questioning technique and how it could be improved. According to my supervisor the interviews went very well. However it was suggested that I should sometimes ask the learners to raise their voices, and also repeat what learners said, for clear transcribing purposes later. Besides this one change, no major changes were made after the piloting phase. Since this change was relatively small, results from the pilot study were also included in the final data set.

(g) Interviews with learners in the main study

Although the original interview schedule ensured uniformity of questions across participants, each particular interview in the main study was eventually slightly different from the others due to the further probing elicited following the interviewees' responses?

I, the researcher, ensured that appointments were made prior to interview dates. In total, 52 learners were interviewed (Table 3.3) during a seven-day period in September 2005. Teachers looked for an available room within the school premises (such as a library, an interview room, a vacant office or a laboratory). As a visitor, I was already familiar to the school's staff, having collected the CTAs from each school earlier at the beginning of the year. However, I again explained the purpose of the study and, after teachers were assured of confidentiality, the interview sessions began.

Table 3.3 presents the interview questions with the necessary reasons for selection.

Table 3.3: An interview schedule for learners

Main question	Reason for question	Possible probing Questions
1. Do you think the questions were set in an unfair or fair way?	To find out what the overall opinion of learners was, with regard to the test.	- Did you find specific questions difficult? Give me an example. - Why?
2. Did you find the language used in the test difficult or not?	To find out whether the English used in the test was of a standard level or too difficult.	- Why? - Would you have preferred the the Natural Science CTA to have been written in Xhosa? (this question was specifically asked for Xhosa learners)
3. Referring specifically to CTA Question 2, this question is about the investigation method. Many teachers complained that this question needed attention. • Do you know what a variable is? • Explain to me in your own words what a variable is. • Did you learn about variables in your class? • When or where?	The overall performance of learners on this question was very poor and the researcher needed to find possible reasons for the under-performance.	
4. Referring to CTA Question 4.2 and Question 5, could you, or could you not, make sense of the graphs?	To find out if there was anything about the graphs that learners might have had problems with or interpreting graphs in general.	- Why?
5. Referring to item 4.1(a):- (i) What do you understand about these diagrams? What are they showing you? (ii) Did the key in item 4.1(a) help you find the formula?	To find out: if the diagrams were useful or not; whether the learners could interpret them; and if they knew that the balls represented atoms.	- Was it useful?
6. Are the types of questions asked in the CTAs different from what you are used to getting in class?	To find out if learners were familiar with the type of questions asked and their opinion on the style of questioning compared to their usual classwork.	- In what way? - Did you get these kinds of questions in your classwork?

The Afrikaans learners were interviewed by me, the researcher, in Afrikaans, after the interview questions had been translated most accurately by a high school Afrikaans teacher. Details of the numbers of learners interviewed face-to face at the different schools are summarised in Table 3.4.

Table 3.4: Details of numbers of learners interviewed in seven schools in Phase III of the investigation

School SES Level	Number of learners		Total
	Male	Female	
Pink (level 1)	0	6	6
Plum (level 2)	4	4	8
Beta (level 3)	4	6	10
Alpha (level 3)	3	4	7
Mars (level 4)	4	4	8
Venus (level 4)	4	3	7
Neptune (level 4)	3	3	6
Total number of learners interviewed	22	30	52

I was aware that the learners might feel intimidated by the tape-recorder, so introductory remarks were made prior to the interview to make each learner feel at ease. This included an explanation of the purpose and value of the research and the need for the interview and tape-recorder. I also reassured the learners that the interview was not a test, and I emphasized the importance of the learners expressing their own thoughts as honestly and freely as possible.

(h) Interviews with teachers – the introduction

Interviews with teachers were used as a complimentary means to corroborate not only the information collected from the quantitative analysis but also the learners' responses obtained from the interviews. Once again I ensured that the appointments were made prior to interview dates. The interviewed teachers were chosen purposefully, based on the school's overall performance in the CTA and the teacher's experience in teaching Grade 9 Natural Science. Six teachers were interviewed during a five day period in September 2005, selected from various schools with different levels of SES.

Teachers were presented initially with extracted learners' comments to read concerning their reactions to the CTA. This presentation was then followed by the introduction of two open-ended more general questions:

- *"How did you find the CTA of last year?"*
  (referring to the Section A booklet)
- *"Do you think they should continue or be discontinued?"*

Sufficient time was allowed to enable the participant teachers to think through each question before responding to it. The interview questions were designed to elicit teachers' considered professional evaluation of the value of the CTA; their attitude towards it; and their possible recommendations for the formulation of subsequent CTAs.

(i) Construction of the more detailed interview questions for the teachers

The interviews with teachers had two main goals. These were to assess the perceived quality of the test using professional and academic criteria such as those suggested by Ebel (1972) and RNCS (DoE, 2002c); and also to obtain recommendations for improving the format and content of a Natural Science CTA in the future.

The more probing, follow-up interview questions were framed according to the criteria suggested by Ebel (1972) and was used to assist teachers to judge and evaluate the educational quality of a test such as a CTA. Ebel's criteria are summarised as follows:

- *Relevance* – Did the items included in the classroom test provide tasks appropriate to the purpose of the test?
- *Balance* – Were the number or proportion of test items evenly distributed among various categories?
- *Efficiency* – Did the test yield a large number of independent scorable responses per unit of time?
- *Reliability* – Did the test yield scores that agree with those obtained from equally good independent measurements of the same achievements?
- *Objectivity* – Were the questions clear enough - with no ambiguity?
- *Specificity* – Did the questions require prior knowledge specific to the content covered by the test?
- *Difficulty* – Were the test questions and the test as a whole appropriate for a Grade 9 learner, i.e. neither too hard nor too easy for the learners?

- *Discrimination* – Did the individual questions discriminate sharply between learners of higher and lower achievement and was there a fair distribution of scores for learners who differ in achievement?
- *Fairness* – Was the test constructed and administered so that each learner had an equal opportunity to demonstrate his or her real achievement in the process skills tested?
- *Speediness* – Was the test appropriate in length for the time available, so that each learner had sufficient time to answer the last question in the test?

Furthermore, according to the RNCS (DoE, 2002c), the Natural Sciences Learning Area covers content validity by:

- Learning Outcome 1 – the development and use of science process skills in a variety of settings;
- Learning Outcome 2 – the development and application of scientific knowledge and understanding; and
- Learning Outcome 3 – appreciation of the relationships and responsibilities between science, society and the environment.

Therefore the CTA test should also have clear Assessment Standards and a clear rubric to mark each section. This was consistent with Ebel's fourth criterion of objectivity (clarity).

During the interviews the teachers were also asked about the specified purposes of the Common Tasks for Assessment as specified in RNCS (DoE, 2002c:79), namely to: "ensure consistency in teacher's judgements" – which was similar to Ebel's criterion of reliability; "increase the accuracy of the assessment process and tools" – which was similar to Ebel's quality of specificity; and "ensure that the school-based assessment tasks properly assessed competencies and achievements" – which resembled Ebel's criteria of balance and relevance.

Three new criteria that seem to have been added to Ebel's earlier criteria for testing were: to "strengthen the capacity for school-based continuous assessment"; to "ensure expanded opportunities for learners"; and to "promote common standard setting" (DoE, 2002c:79).

With these criteria in mind, I sought relevant evidence by listening to the tape recordings, requesting teachers and learners to evaluate various aspects of the quality of the CTA test. Where possible, this new evidence was used to support or enlarge or otherwise modify the existing findings derived from the quantitative analysis. Thus the data derived from the interview analysis, which is reported in detail in the next chapter, was used to link or triangulate both the quantitative and qualitative data generated from the responses produced by the utilization of the various instruments of investigation.

(j) Ethical considerations

Confidentiality was a central ethical issue in this study. The identities of the willing participants and the names of the schools were withheld. Also, the names of all learners whose CTA responses were analyzed remain anonymous.

3.5 Chapter summary

This chapter has outlined the research design used in the study. It has described the research questions, the selection of multiple methods of data collection, validation and analysis via pilot testing, focused interviews and large scale testing prescribed in the classroom. It has described in some detail the characteristic profiles of the samples with respect to their origin, context, background and size, gender and SES. The quantitative study was regarded primarily as an *ex post facto* investigation with additionally generated qualitative findings that were subsequently triangulated, explained, illuminated, moderated, expanded or corroborated through the production of supplementary interview data. The researcher has described the several phases and components of the study in sufficient operational detail so that its format can be replicated elsewhere if and when required.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents both the quantitative and qualitative findings of phases II and III of the investigation in an integrated manner. It analyses and discusses the performances of 1572 learners in Section B of the Grade 9 Natural Science Common Tasks for Assessment (CTA) (2004) (see Appendix 1) in terms of the process skills, Learning Outcomes and Assessment Standards specified in the Revised National Curriculum Statement (RNCS) Grades R-9 (Schools) Policy of the Department of Education (DoE, 2002c). To begin, the Common Tasks for Assessment (CTA) examination scripts were collected from 12 different schools in the Western Cape in 2005. The learners' scores for each item in Section B of the CTA (2004) were then recorded systematically using Excel sheets and the Windows computer programme Statistica, Version 7.

In this chapter, a range of statistical analyses are performed using the scores and parameters for each item, and on the data as a whole as done in a study by Beaumont-Walters and Soyibo, (2001). At the same time, qualitative supporting data obtained during interviews conducted with 52 learners sampled from all twelve schools in the Western Cape, and subsequently with their teachers, are also presented. These instances and examples of evidence illustrate or moderate the statistical findings (with caveats) in a variety of school contexts. The findings of the study are presented using both descriptive and inferential statistics, with excerpts from the interviews and explanations being incorporated into the narrative to support the empirical findings.

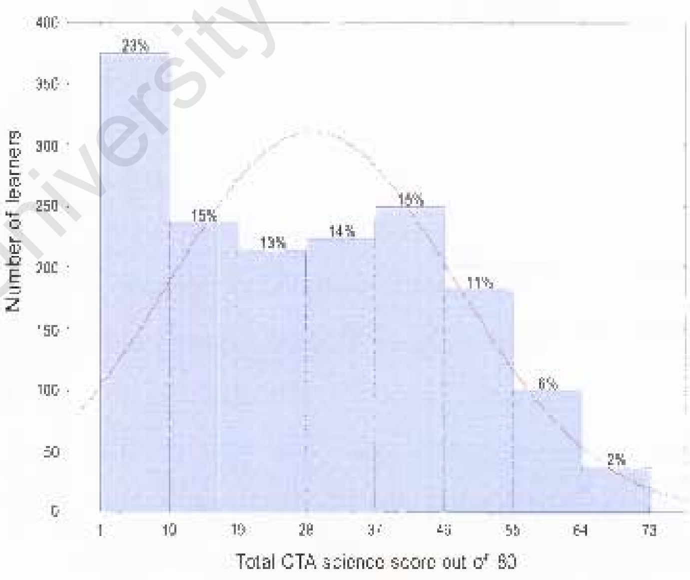
Patterns in the performances and responses from teachers and learners are also reported and analyzed. A discussion of the results - and how they corroborate the findings of a number of previous studies on process skills, content and misconceptions - follows at the end of each section. Because of the length and complexity of this chapter, a convenient summary of the main findings is presented at the end of the chapter on section 4.9, to which the reader may refer.

4.2 The performance of the learners on the Natural Science CTA as a whole

Figure 4.1 presents the distribution of the raw scores of the 1572 learners from the 12 schools, grouped as a whole, for their performance totals on Section B of the 2004 Grade 9 Natural Science CTA. The highest score obtained by any learner was 73 marks out of a possible maximum of 80 marks, or 91%. The lowest score was 1 mark out of 80. The mean and standard deviation were 30.6 ± 17.5 i.e. ($38.3\% \pm 21.9\%$).

The raw score totals of the 1572 learners were not normally distributed, according to the Lilifors test for normality ($p<0.01$) and the K-S test for normality ($p<0.01$), which implies that non-parametric statistical tests will more appropriately be used as tools of analysis in this chapter. The percentages on the top of each column designate the percentage of the whole sample that scored in the specified 9-mark range; e.g. 14% of the learners scored between 28 and 36 marks in Figure 4.1.

Figure 4.1: Distribution of the performance scores on Section B of the 2004 Grade 9 Natural Science CTA for the learners from 12 schools (n = 1572)



For the detailed item analysis which follows in section 4.3 below, according to Ebel (1972:386) learners' scores in the "upper" range are defined as those lying in the top 27% of the distribution, *viz.* those with high score totals between 44 and 73 marks out of 80 (i.e. achievements from 55% to 91%) in this instance. Learners defined as falling in the "lower" range (i.e. those with scores in the bottom 27% of the distribution) have score totals ranging between 1 and 17 marks (i.e. they score from 1 % to 21 %).

At its lower end, the positively skewed distribution of scores in Figure 4.1 did not follow a normal curve at all. Furthermore, the fact that 23% of the learners scored less than 11 out of 80 may be regarded as a concern to teachers and curriculum planners if their focus is on the attainment of basic levels of achievement.

According to the Declaration of the framework for the assessment and promotion of learners in Grade 9… (Government Gazette No. 25699), the descriptor code for "partially achieved" is 35%-39% and 1-34% for "not achieved" (DoE 2003c:9). The mean score for learners' overall performance was 38.3% which meant that the learners had an average rating of "partially achieved".

The following section 4.3 will present the findings for research sub-questions 1 and 2: stated on page 78.

4.3 Learners' performances on understanding scientific concepts, recall of previous knowledge, use of process skills and their misconceptions

Research sub-question no.1 asked:

"On which of the 25 items in Section B of the 2004 Grade 9 CTA in Natural Science did the mean scores for the combined sample of 1572 learners from 12 schools, taken as a whole, meet or exceed the specified minima for acceptable levels of performance?"

4.3.1 Learners' achievement on CTA Question 1 (Topic: Electricity)

CTA Question 1 tested the learners' abilities to achieve Learning Outcome 1 (LO1) (scientific investigations), Learning Outcome 2 (LO2) (constructing science knowledge) and Learning Outcome 3 (LO3) (science, society and the environment). The process skills were 'interpreting information', 'inferring', 'communicating science information', 'decision making', 'observing' and 'comparing'.

For CTA Question 1 it was found that, for the combined sample of 1572 learners taken as a whole, acceptable levels of achievement (as determined in Chapter 3, page 74) were attained on items numbered 1.1, 1.3 and 1.4 but not on item 1.2 for which fewer than 50% of learners achieved the acceptable level, as recorded in Table 4.1.

Table 4.1: Basic descriptive statistics for the performance scores of the combined sample of learners on Question 1 of Section B in the 2004 Grade 9 CTA examination in Natural Science (n = 1572)

CTA item No.	The science content of the item	Mean ± SD	Mean score (%)	Possible scores	Acceptable minimum score	f (%)
1.1	Draw a circuit diagram.	1.87 ± 1.37	47%	0 1 2 3 4	2	368 (23.4%) 244 (15.5%) 428 (27.2%) 293 (18.6%) 239 (15.2%)
1.2	Can the TV be connected in series?	1.19 ± 1.08	40%	0 1 2 3	2	586 (37.3%) 311 (19.8%) 460 (29.3%) 215 (13.7%)
1.3	Do you think the children can use the plug for the TV to boil water in a kettle rated at 220 V; 1.5 kW AC?	1.19 ± 0.85	60%	0 1 2	1	441 (28.1%) 386 (24.6%) 744 (47.4%)
1.4	The children priced what they need to carry out their plans. Should they or should they not buy these items?	2.67 ± 1.53	53%	0 1 2 3 4 5	3	150 (9.5%) 243 (15.5%) 313 (19.9%) 391 (24.9%) 224 (14.3%) 251 (16%)

SD = standard deviation
f = frequency of the score (out of 1572 respondents)
(%) = the percentage of the sample obtaining a particular score

4.3.2 Learners' misconceptions on CTA Question 1

Research sub-question no.2 asked:

> **"Were the learners' misconceptions in knowledge and skills found to be similar to those already known in the published literature, and did there appear to be any misinterpretations of certain questions when representative samples of English-speaking, Afrikaans-speaking and Xhosa-speaking learners had their CTA answers scrutinized in depth through interviews with teachers and learners, as well as on their scripts?"**

This research sub-question will now be answered, analysed and discussed for CTA items 1.1 to 1.4, one by one.

4.3.2(a) Misconceptions related to item 1.1

Figure 4.2 reproduces the textual presentation of CTA item 1.1. It also supplies the memorandum of expected correct answers and responses, the process skills tested and the acceptable minimum performance score.

Figure 4.2: CTA item 1.1 and its expected responses

Item 1.1: *To convince their parents the two children draw a circuit diagram showing how they plan to electrify the house. Draw a labelled circuit diagram that the two children can use. Include the following in your diagram switches, battery, 4 lights (bulbs) and the TV.*

Expected responses:

- *The learners draw the symbol for the battery.*
- *The learners indicate the need for a source of energy.*
- *The learners draw separate switches in series with each bulb and the TV.*

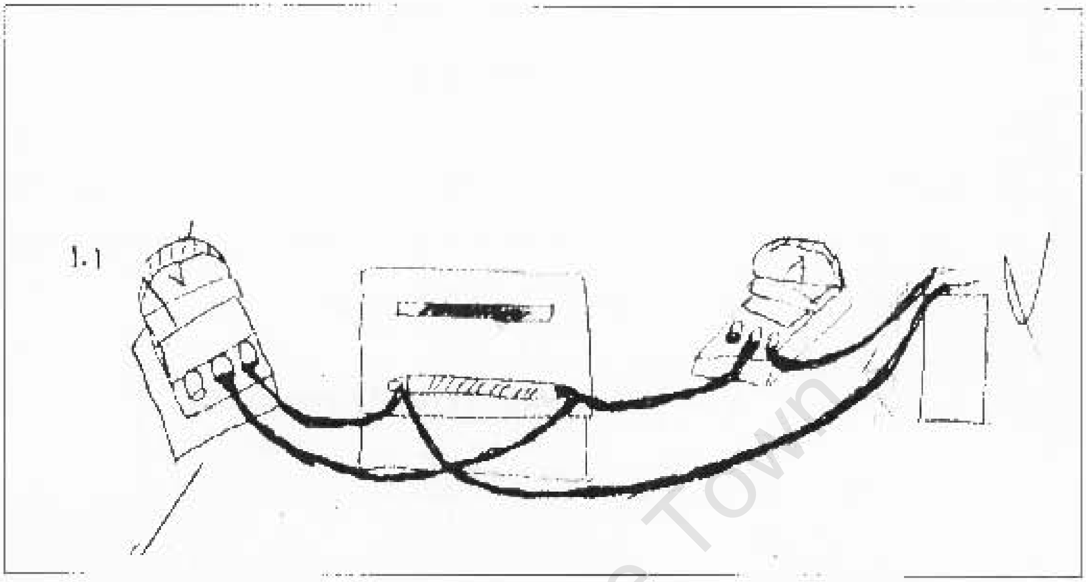
Process skills tested:

- *Communicating science information*
- *Recall meaningful information.*

Acceptable minimum performance score: *2 out of 4.*

A number of alternative answers and variant responses to item 1.1 were noted in the learners' scripts, and these also became apparent during the recorded interviews. Figure 4.3, for example, reproduces a 15 year-old learner's incorrect attempt to construct a circuit diagram in response to item 1.1. This learner may have used incorrect knowledge of a practical, perhaps performed in class or demonstrated by the teacher, as seen in the learner's faulty attempt to draw the diagram, and explained below.

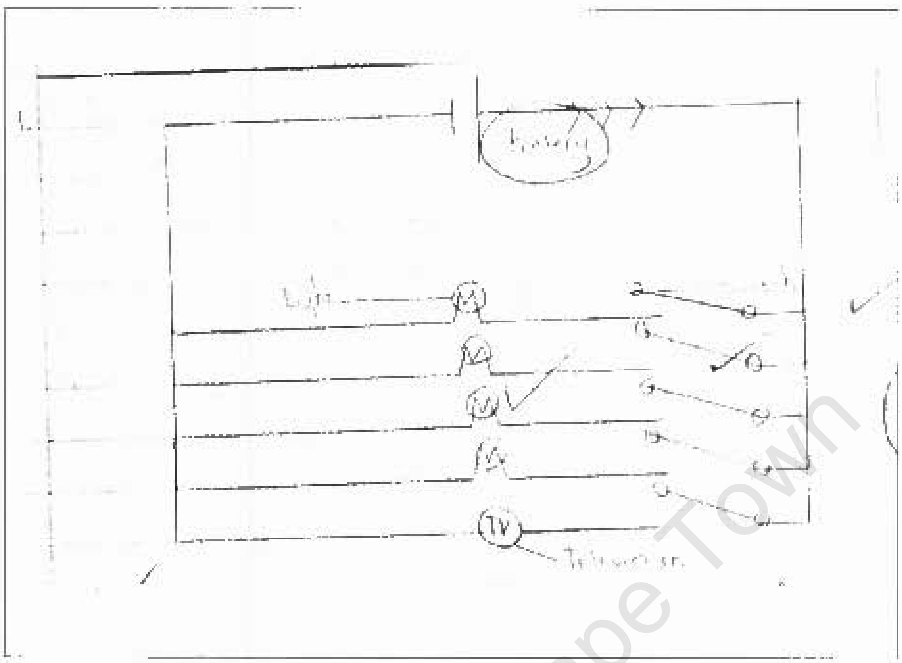
Figure 4.3: A learner's response to item 1.1 showing a misconception in regard to circuit diagrams



When using representations in physics, the purpose of a circuit diagram is to show how the various components of a circuit must be sequenced and connected in practice. Instead of drawing pictures of what the components actually look like, certain standard symbols are used to represent each component instead (Brink & Jones, 1984; Moodie, 1990). It seems that the above learner had a misconception about circuit diagrams. In Figure 4.3 he drew a picture of what each component looks like, instead of using the conventional symbols. Perhaps the test-setter's wording of the item in this question should have been more specifically directed in order for the learners to have used symbols to represent each component in the circuit diagram.

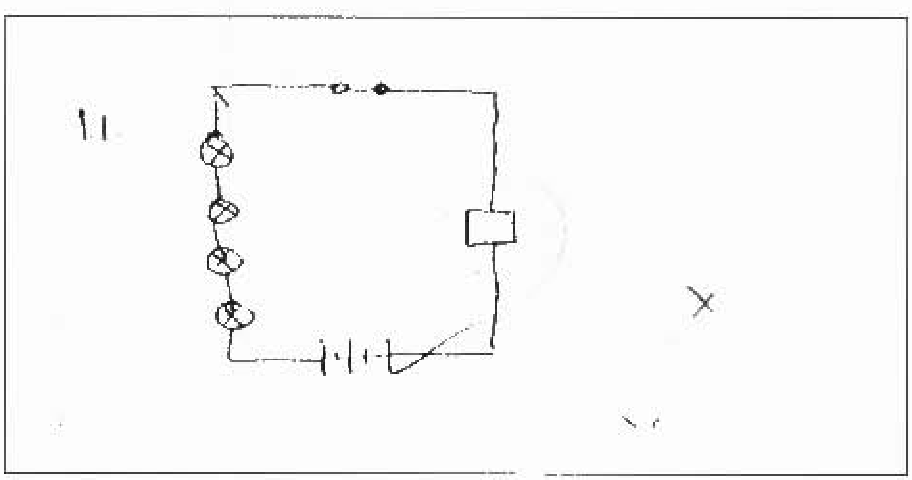
Figure 4.4 depicts another learner's written effort in response to item 1.1

Figure 4.4: A second learner's response to item 1.1 showing a misconception with respect to batteries and cells



In Figure 4.4 it can be seen that the learner drew only one cell to represent a battery and did not indicate that a battery consists of two or more cells connected together, as defined in many science textbooks (e.g. van Zyl *et al.*, 2001:9). The learner's confusion between a 'battery' and a 'cell' was evident in various responses, and this type of error has been noted in a previous study by Hendricks (1999:183) in which learners indicated that they regarded cells as batteries, and batteries as cells, and they did not make the distinction.

Figure 4.5: A third learner's response to item 1.1 showing a misconception with respect to series and parallel connections



In order to understand CTA item 1.1, all learners should have had an existing working knowledge of parallel and series connections. In Figure 4.5 it can be observed that the learner drew the positions of the bulbs incorrectly. The bulbs should have been drawn connected in parallel, and not in series; and each bulb in the diagram should have had its own switch. The above response by the learner depicted a misconception with regard to parallel and series connections. Knowledge of these principles was based very much on prior learning, with an Assessment Standard being specified as "recall meaningful information" in the 'Resource Materials for the Senior Phase' of the South African Department of Education's (WCED, 2005:17). Application of this knowledge was required in this item. In the RNCS (DoE, 2002c), the minimal requirements for a Grade 9 learner with regard to knowledge of concepts have not been mentioned. Could this be the reason why many learners did not know how to draw a circuit diagram?

These CTA problems, manifested and depicted by learners in the representation of circuit diagrams, were consistent with earlier research findings (Pudlowski, 1988; Hendricks, 1999; Shipstone, 1985a).

4.3.2(b) Misconceptions related to item 1.2

Figure 4.6 reproduces the textual presentation of CTA item 1.2 and supplies the expected correct answers.

Figure 4.6: CTA item 1.2 and its expected response

Item 1.2: *Can the TV be connected in series with the light bulbs? Give two reasons for your answer.*

Process skills tested:

- *Decision making*
- *Recall meaningful information (intellectual skill)*
- *Application of prior knowledge.*

Expected response: *No.*

Reasons (any two):

- *You would not be able to switch on or off the TV and the lights independently.*
- *The TV (or bulb) would not operate at the correct voltage (or potential difference) because the 12V supplied by the battery would be divided across both.*
- *An incorrect current would flow through the TV.*

Acceptable minimum performance score: *2 out of 3.*

This item tested the learners' ability to make a decision based on connecting electrical appliances correctly, and it assessed the application of knowledge. A learner had to have both prior knowledge and a comprehension of parallel and series connections before answering the question correctly. Although the acceptable minimum score was set at 2 out of 3, normally one would have expected the majority of learners to have attained 100% for this item. Since it is assumed that this section had already been taught thoroughly in Grades 8 and 9, it was anticipated that learners should have been able to answer such questions easily. However a number of alternative answers and variant responses to item 1.2 were noted in the learners' scripts and during the interviews. These are recorded verbatim and discussed below.

At the end of each learner's cited response, an additional record has been attached of that particular learner's status or overall performance score on the CTA as a whole (i.e. on all 25 items collectively), expressed as a percentage. As defined earlier in section 4.2 on page 96, a "*strong*" learner had a score between 55% and 91%; a "*middle*" range learner scored between 22% and 54%; and a "*weak*" learner had a CTA total score of less than 22%.

Responses were observed as follows, in the language category indicated, followed by a brief explanation, comment or discussion.

Learners' responses in the English group:

> *"Yes it can, but it would be better if it was not. If it is, then when you switch the TV off the lights will go off. They will react together".* *(68%)(strong)*

This "strong" learner did not know that the 12 volts supplied by the battery would be divided across both components in the circuit, and therefore the bulb in series would not operate at the correct voltage. It seems that the learner found great difficulty in distinguishing between current and voltage which has been found in other studies (Evans, 1978).

> *"Yes, if one light bulb blows the others will still burn, therefore the TV will still be able to play. Less power is being used".* *(48%)(middle)*

This learner did not seem to understand that the 12V supplied by the battery would be divided across both and therefore the TV (or bulb) would not operate at the correct voltage. The learner also did no seem to know the difference between a series and a parallel connection.

> *"No. The light bulbs and the TV would stand a high chance of exploding from all the electricity".* *(50%)(middle)*

This learner got the answer partially correct but it seems that this learner does not see current as a conserved quantity. This learner does not seem to take 'resistance' into consideration. This has been noted in prior research as a common alternative conception of 'current' (Stanton, 1990).

> *"No because the used-up electricity has to go to the negative side of the battery and it can't do that if the TV is in the way".* *(45%)(middle)*

This learner appears to think that only one terminal of the battery is active. This response relates to a prior notion of batteries, i.e. some students believe in the "unipolar model" (Freddette & Lockhead, 1980:196).

These items 1.1 and 1.2 were designed to elicit the prior knowledge of learners, and were intended to expose whether or not they understood certain concepts.

> *"Yes, series circuits are very strong as in high voltage: it will pick up anything on the circuit".* *(25%)(middle)*

This learner had a serious misconception about series circuits. Although the ammeter readings are the same everywhere, the potential is actually divided.

Learners' responses in the Afrikaans group:

> *"Ja. As dit in serie geskakel is, dan sal die gloeilampe brand".* *(6%)(weak)*
> Yes. If it is connected in series, the bulbs will burn.

This learner did not realise that the 12 volts supplied by the battery would be divided across both of the components in the circuit, and thus the bulb or TV would not be able to operate at the correct voltage.

> *"Ja, want as een van die gloeilampe breek dan gaan die TV nogsteeds werk. Die TV kan jy an/af sit en dan sal die ligte ook nie aan gaan as die TV aan is nie behalwe as jy dit aansit".* *(40%)(middle)*

> Yes, if one of the bulbs break the TV will still work. The lights will not be switched on if the TV is switched on or off, unless you switch it on separately.

It appears that this learner did not know the difference between parallel and series connections. When the circuit is connected in parallel, the TV will still work if one of the bulbs breaks, but this cannot happen if the circuit is connected in series.

Learners' responses in the Xhosa group:

> *"Yes. Because each bulb has its own switch".* *(24%)(middle)*

In this response, the learner assumed that if each bulb has its own switch, the TV and lights could be switched on or off independently. Again, a misconception had occurred that might lead to problems in further learning, if not made clear to the learner.

> *"Yes because the light bulbs are charging the battery and you can operate low energy. One fluorescent light to charge a battery".* *(13%)(weak)*

From the response given by this "weak" learner, one may speculate whether the learner was ever taught the concepts of series and parallel connections, since the answer did not make sense at all.

> *"Yes. Because you can switch TV when other places not switched, and you can watch TV no matter there is no electricity in other room".* *(21%)(weak)*

It seems that this learner believed that, if the TV were connected in series with the light bulbs, then the TV could be played independently, which is wrong, since this is related to a parallel connection.

From the above excerpts, there was evidence that individual learners possessed an inadequate understanding of series and parallel connections. Recall of prior knowledge can occur only if learners are initially taught properly and thoroughly. The fact that voltage was not used in the reasoning of learners for item 1.2 indicates that learners either were not taught the concept properly or were not taught at all. Another explanation could possibly support many previous studies that reveal how few students tend to use the concept 'voltage' to solve problems, since it is not seen as a cause of current flow but is merely induced by the current (Stanton, 1990). Decision making, which is a process skill emphasised in the 'Resource Material' of the Natural Science Learning area (WCED, 2005) and the RNCS (DoE, 2002c) can be accomplished only if the learner has sufficient knowledge of a particular concept and principle. I also agree with recommendations given from previous research that learners should be exposed to a variety of different questions when practising series and parallel connections (Hendricks, 1999). If learners are given a variety of different manageable questions, authentic understanding of certain concepts can be consolidated. However, it can be argued that specifications in the Grade 9 curriculum (DoE, 2002c), as far as content is concerned, are far too vague. The extent of knowledge relating to an electrical circuit can vary from school to school. At a Grade 9 level, concepts and minimal requirements should be made more clear and simple to understand. This is a crucial year since the basics that form the foundation for further learning are essential. Parallel and series networks are only referred to very specifically in the Grade 11 curriculum (DoE, 2004a).

4.3.2(c) Misconceptions related to item 1.3

Figure 4.7 reproduces the textual presentation of CTA item 1.3, and it supplies the expected correct answers.

Figure 4.7: CTA item 1.3 and its expected response

Item 1.3: *Do you think the children can use the plug for the TV to boil water in a kettle rated at 220V: 1.5Kw AC? Give a reason for your answer.*

Expected response: *No.*

Reasons (any of these reasons):

- *The voltage of the TV is too low.*
- *The kettle is rated for AC but the battery is DC.*
- *The battery cannot supply enough energy to make it practical.*
- *The time to boil water using a 12V supply is too long.*

Process skills tested:

- *Decision making*
- *Recall meaningful information (intellectual skill).*

Acceptable minimum performance score: *1 out of 2.*

A number of alternative answers and unanticipated responses to item 1.3 were noted in the learners' scripts and during the interviews. Several examples were:-

Learners' responses in the English group:

"No, because the TV and kettle are two different items altogether". *(18%)(weak)*

The concepts of voltage, AC and DC, were not necessarily dealt with in Grade 9. Only 47% of the learners obtained the full two marks. This learner got the first part of the question correct but could not give an adequate reason.

"No because, if the water overboils, they can electrocute the TV's wires". *(35%)(middle)*

This learner also responded correctly to the first part of the question but could not give the correct scientific reason. It seems that the learner gave only a safety measure precaution which related to the spilling of water on electric wiring or plugs. The word 'electrocute' had been used out of context since to be 'electrocuted' means to be killed by electricity.

"Yes, you can change any plug to a different wire". *(59%)(middle)*

The response of this learner showed how vaguely worded the question was. The learner correctly thought that a plug (either two point or three point) could be connected to other wires. Possibly the learner had seen this done. However, the correct response refers to the **lead** of the TV, not just the plug. According to a consulted qualified electronic technician, the wording of this item was very vague. It should have been written as: "Do you think the children can use the lead for the TV...." Instead of "....can use the plug..."

Also, from a practical point of view, the kettle and TV had different sockets depicted in the diagram, and therefore the same lead could not have been used. This should have been given as another possible reason. Examiners of any standardised test should be aware of the concepts that have been taught thoroughly enough in schools and the practical nature of the question. Otherwise certain questions could be rendered unfair.

Although an extract was given in the CTA describing the different voltages used for the kettle and TV, the learners quoted above could not give a reasonably good explanation. A possible explanation for this might be that the concepts of voltage, AC and DC either were not always taught in depth in Grade 9, or were not taught at all. As mentioned in the literature review, studies have indicated that learners have difficulty in understanding the concept 'voltage' and that it is recommended that it be taught in the latter years of secondary education (Levinson, 1994; Shipstone, 1985b). Teachers and examiners should be aware of this and choose appropriate questions. Therefore it is important that teachers be given an outline of the CTA content or syllabus well in advance so that they can prepare learners for the CTA tests. However, this suggestion is sometimes regarded by some researchers as a pitfall in assessment for standardisation since it involves teaching specific content and therefore weakens the inferences made about learners' knowledge (Mehrens, 1989). According to Mehrens, proper inferences can only be made when assessing a broader range of skills instead of specific content. However, it can be argued that teachers and learners should have a fair chance to tackle novel questions put to them.

The above argument was mentioned by one teacher in an interview in 2005 who responded to the introduction of CTAs by the Department of Education by saying:

> *"If they give us a syllabus and indicate to us the kind of content that we need to be teaching the students, as well as giving us a sample, the CTA that everybody does, we can work throughout the year doing that and we can also see the level and the kinds of questions asked so that we can adapt other sections of the work in a similar fashion – but doing the CTA at the end of the year .....uhm... I don't think it is a good idea".*

Although the above comment seemed to dispute the basic premise of outcomes-based education (which claims to be not content-driven), it was relevant if one took into account the interest of the learner. As Wellington (1989:18) stated, a more structured syllabus could create "an ideal balance between process, content and context". It could be argued that the processes of science are important to develop a "scientifically literate" individual as emphasized in the RNCS (DoE, 2003b). However, one can develop these skills properly and fairly only if the content is also made explicit for the learners over a long enough period of **time**, in order for them to grasp certain concepts so that they can use important skills like **'decision making'** efficiently. A report done on the implementation of the CTAs also recommended that the CTAs be delivered earlier to schools to provide more time for the moderation of performances of Section A and Section B (DoE, 2004b).

Nevertheless, there was also a concern that the introduction of national and standardised tests into schools could narrow the scope of the curriculum if teachers were pressured by the demand to produce higher test scores. Referring to the above teacher's comment, teachers might end up spending a considerable amount of time giving to learners selected practice items that are similar to those that would be forthcoming on the test. Possibly this would result in the test becoming the curriculum where teachers taught too closely to the limited content of the test (Mehrens, 1989). Therefore, it would seem important that a CASS mark, which accounted for 75% of the total mark, be kept separate from the CTA mark which accounted for 25%.

Learners' responses in the Afrikaans group to CTA item 1.3:

"Ja, want die battery is baie vol krag" . (5%)(weak)

Yes, because the battery is full of power.

"Ja, want die TV kry krag by die gloeilampe en die ketel kan krag kry by die TV". (8%)(weak)
Yes, because the TV can get power from the light bulbs and the kettle can get power from the TV.

"Ja, omdat 'n krag prop het 240V wat genoeg is dat die ketel ook daarop kan werk". *(63%)(strong)*

Yes, because a plug has 240V which is enough power for the kettle to work.

This learner believed that any plug had a voltage of 240V.

"Ja, want 'n kragprop kan vir enige elektrise toestel gebruik word(65%)(strong)

Yes, because a plug can be used for any electrical appliance.

Learners' responses in the Xhosa group:

"Yes because a plug is to plug a TV or stove or kettle". *(8%)(weak)*

"No because that steam came from the boiling water affect the TV". *(24%)(middle)*

"No, because they can touch wire and burn up". *(6%)(weak)*

"No, you can't mix two plugs of electricity together it is dangerous". *(16%)(weak)*

It seems that the above learners did not take into account the different operating voltages between the kettle and TV. Their responses were non-scientific and related instead to the general safety measures used in electricity. The fact that one full mark was allocated for answering 'No', plus only one mark for the correct reason, explained why the mean was above average (1.2 out of a total score of 2). Many of the learners might have had the first part of the question correct but then gave the wrong explanation.

It was felt by some of the interviewed teachers that the mark allocation for this item was not defensible, because supplying a reason required a great deal of thought and two marks were insufficient. Correct reasoning is a true indication of the learner's grasp of a concept, and one can also argue that these learners might have guessed an answer to the first part of the question.

Figure 4.8 reproduces the textual presentation of CTA item 1.4 and supplies the expected correct answers.

Figure 4.8: CTA item 1.4 and its expected responses

Item 1.4: The children priced what they need to carry out their plans.

TV (2nd hand)	**R100.00**	**Solar battery charger**	**R200.00**
4 Fluorescent bulbs	**R30.00**	**Switches; plug socket**	**R50.00**
Battery	**R300.00**	**Connectors-scrap**	**0**

The children know their father has R1 000 which he keeps for emergencies.

Think of the circumstances in which these children live.

a. In one sentence advise the children as to what you believe they should do. Should they or should they not, buy these items?

Expected response:

- *Buy the battery, bulbs, TV.*
- *Do not buy the battery, bulbs, TV.*

Acceptable minimum score: *3 out of 4.*

b. In two or three sentences give the most important reason for your advice.

Expected Responses:

Buy	**Do not buy**
1. Allowing the children to install and run this system will give them self confidence. *2. The children will have light with which to study.* *3. It gives the children responsibility.* *4. Parents show trust in the children.* *5. Improvements in living conditions will lead to a desire for more improvement and innovation and harder work.* *6. Light means the day can be extended; productive study and work can be undertaken after dark – they can recoup their father's R 1000 and make more money.* *7. TV means exposure to new ideas, new knowledge.* **Process skills:** • *Interpreting information* • *Observing and comparing* • *Decision making.*	***1.*** *A TV is a luxury that the children cannot afford.* ***2.*** *They cannot afford recharging and maintenance.* ***3.*** *They have managed without light and TV already.* ***4.*** *TV is anti-social; they will stop talking to friends.* ***5.*** *They will have to work harder to make more money to maintain the new life style.* ***6.*** *They will have no money for emergencies.*

A number of alternative answers and unexpected responses to item 1.4 were noted in the learners' scripts and during the interviews. These responses were observed as follows, in the language category indicated.

Learners' responses in the English group:

> *"I think they should not buy the items because someone might break into their 'hok' and steel it. They can only buy it if they live in a stable house. And with burglar bars and safety gates".* *(16%)(weak)*

The learner related his situation to the question posed. This is an example of how the CTA elicited responses from learners by relating science in context to the individual and society.

These type of questions make learning more interesting and is a typical example of a "real life" approach to science teaching where learners have to make a decision relating to society and their own situation. This view is supported by (Aikenhead. 1994:49 and Rillero, 1998:3).

> *"They should not buy the items because what if someone in the family gets hurt badly then they can use the money for the emergency".* *(13%)(weak)*

> *"I think that the children should definitely buy these items. These items are all relatively cheap and affordable plus after purchase, there still would be a reasonable amount of emergency money left over. Electrification of a house will bring extra comforts and benefits to the family".* *(74%)(strong)*

> *"They should buy all essential items because this will improve their standard of living and as they claim make studying easier for them".* *(59%)(strong)*

Learners' responses in the Afrikaans group:

> *"Nee, hulle moet nie. As iemand daadlik siek gaan word sal hulle daardie geld nodig hê. Die pa mag dalk die plaas verloor en dan daardie geld gebruik om hulle weer op hul voete te kry".* *(60%)(strong)*

> No, they must not. If someone should get sick, they would need that money. The father could lose the farm and therefore need the money to put them back on their feet again.

> *"Hulle moet dit koop, want dus goedkoop en goed vir hulle huis. Hulle ma kan kas maak as daar elektrisiteit is. Hulle kan leer sonder om 'n kers aan te steek".* *(18%)(weak)*

> They must buy it because its cheap and needed for their house. The mother can make food if there is electricity available. They can study without having to use candles.

Learners' responses in the Xhosa Group:

> *"They should buy it. They can learn from TV how to use or connect electricity. It will be easier for them to study".* *(9%)(weak)*

> *"They should not buy the items. Their family is poor and need the money. There is no income either than the one they get from their vegetables.*

It will take a great amount of time to bring back the money".
(35%)(middle)

Judging from the above responses from the learners, it was clear that this was an open-ended question. There was no clear-cut right or wrong answer. It was based on decision-making and targeted some of the attitudes and values of learners which are encouraged under the new curriculum. However, only half of the learners achieved the acceptable minimum score. The other half must have struggled with this open-ended question.

4.3.3 Learners' achievement on CTA Question 2 (Topic:Variables and Graphs)

Research sub-question No.1 on page 97 will now be answered for the learners' achievements on CTA Question 2.

For CTA Question 2 it was found that, for the combined sample of 1572 learners taken as a whole, acceptable levels of achievement were attained only on item 2.4, but not on items 2.1, 2.2, 2.3, 2.5, 2.6, 2.7, 2.8 and 2.9 for which fewer than half of the learners achieved the acceptable specified level, as recorded in Table 4.2.

Table 4.2 presents the details of the overall performance of the combined sample of 1572 learners on CTA Question 2.

Table 4.2: Basic descriptive statistics for the performance scores of the combined sample of learners on Question 2 of Section B in the 2004 Grade 9 CTA in Natural Science (n = 1572)

CTA item no.	The science content of each item	Mean ± SD	Mean score (%)	Possible scores	Acceptable minimum score	f (%)
2.1	Describe a variable that they should control.	0.12 ± 0.33	12%	0 1	1	1380 (87.8%) 192 (12.2%)
2.2	Which variable do they change? (independent variable)	0.27 ± 0.45	27%	0 1	1	1142 (72.7%) 430 (27.4%)
2.3	Which variable do they measure?	0.77 ± 0.90	39%	0 1 2	1	858 (54.6%) 215 (13.7%) 499 (31.7%)
2.4	Which variable do they calculate?	0.53 ± 0.50	53%	0 1	1	738 (47%) 834 (53.1%)
2.5	Which variable is the dependent variable in their investigation?	0.13 ± 0.34	13%	0 1	1	1361 (86.6%) 211 (13.4%)
2.6	Write down the matter they investigate.	0.35 ± 0.70	18%	0 1 2	1	1214 (77.2%) 158 (10.1%) 200 (12.7%)
2.7	Describe, in writing, the method they follow to answer the problem they are investigating. Include a circuit diagram.	0.91 ± 1.09	18%	0 1 2 3 4 5	3	734 (46.7%) 450 (28.6%) 240 (15.3%) 100 (6.4%) 36 (2.3%) 12 (0.8%)
2.8	Draw a graph of the magnitude of the resistance against the length of the pencil lead included in the circuit.	1.09 ± 1.21	36%	0 1 2 3	2	750 (47.7%) 263 (16.6%) 226 (14.3%) 333 (21.2%)
2.9	Give the conclusion that the children reach using the graph of their results.	0.98 ± 1.45	25%	0 1 2 3 4 5	3	886 (56.4%) 280 (17.8%) 174 (11.1%) 118 (7.5%) 8 (0.5%) 106 (6.7%)

Mean = average score
f = frequency of the score
SD = standard deviation
(%) = the percentage of the sample obtaining a particular score

CTA Question 2 focused on LO1 and LO2. The skills tested were 'planning science investigations' i.e. 'identifying variables'; 'communicating science information' and 'interpreting information'.

For the combined sample of 1572 learners, the mean scores on almost all the items were low, ranging between 12% and 53%. For item 2.1, most of the learners could not describe the variable that they had to control; for item 2.2, 73% of learners could not identify the variable that had to be changed (the independent variable); and for item 2.5, most could not describe the dependent variable in the investigation. These results were strongly consistent with the findings of Sadeck (1999) in which 173 Grade 7 learners were tested on the investigative method. Their performances showed that they were unable to identify a dependent or independent variable and the need for a control. This might mean that they were unable to deal with the cognitive demands of the question which was classified under a high level advanced cognitive competence, i.e. scientific investigation (Green & Naidoo, 2006).

4.3.4 Learners' misconceptions on CTA Question 2

Research sub-question No. 2 asked:

"Were the learners' misconceptions in knowledge and skills found to be similar to those already known in the published literature; and did there appear to be any misinterpretations of certain questions when representative samples of English-speaking, Afrikaans-speaking and Xhosa-speaking learners had their CTA answers scrutinized in depth through interviews with teachers and learners, as well as their scripts?"

This research sub-question will now be answered, analysed and discussed for CTA items 2.1 to 2.9.

Figure 4.9 reproduces the textual presentation of CTA items 2.1 to 2.9 and it supplies the memorandum of expected correct answers and responses.

Figure 4.9: CTA items 2.1 to 2.9 and their expected responses

Item 2.1: Describe a variable that they should control (keep constant).

Expected responses:
- *The thickness of the pencil lead.*
- *The type (hardness) of the pencil lead.*

Process skills:
- *Planning science investigations*
- *Interpreting information.*

Acceptable minimum score: *1 out of 1*

Item 2.2: Which variable will they change?

Expected response:
- *The length of the piece of pencil lead connected in the circuit.*

Process skills:
- *Planning science investigations*
- *Interpreting information.*

Acceptable minimum score: *1 out of 1*

Item 2.3: Which variables do they measure using meters?

Expected response:
- *Voltage across the pencil lead and the current through the pencil lead.*

Process skills:
- *Planning science investigations*
- *Interpreting information.*

Acceptable minimum score: *1 out of 2*

Item 2.4: Which variable do they calculate?

Expected response:
- *The resistance.*

Process skills:
- *Planning science investigations*
- *Interpreting information.*

Acceptable minimum score: *1 out of 1*

Item 2.5: Which variable is the dependent variable?

Expected response:

- *The resistance.*

Process skills:

- *Planning science investigations*
- *Interpreting information.*

Acceptable minimum score: *1 out of 1*

Item 2.6: Write down the matter they investigate.

Expected response:

- *How is the resistance of 'pencil lead' affected by its length?*

Process skills:

- *Planning science investigations*
- *Interpreting information*
- *Raising questions about a situation.*

Acceptable minimum score: *1 out of 2*

Item 2.7: Describe in writing, the method they follow to answer the problem they are investigating. Include a circuit diagram.

Expected responses:

- *Method for the investigation*
- *Vary the length of 'pencil lead' in the circuit.*
- *Control variables, e.g. ensure the hardness and thickness of the pencil lead is always the same.*
- *Take voltmeter and ammeter readings.*

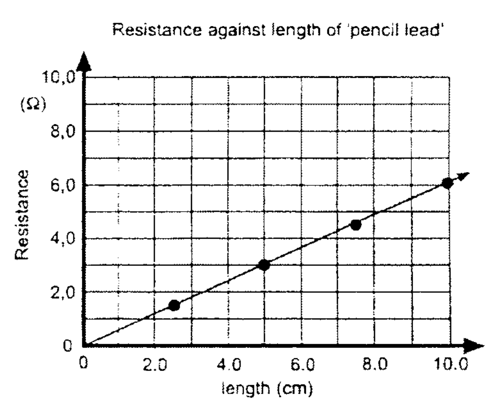
Process skills:

- *Planning science investigations*
- *Interpreting information*
- *Communicating science information.*

Acceptable minimum score: *3 out of 5*

Item 2.8: *Draw a graph of resistance against the length of the pencil lead included in the circuit. Fully label the axes and give your graph a heading.*

Expected response:



Process skills:

- *Application of knowledge*
- *Communicating science information.*
- *Recording information.*

Acceptable minimum score: *2 out of 3*

Item 2.9: *Give the conclusion the children reach using the graph of their results. (Give the conclusion in words and mathematical symbols.)*

Expected responses:

- *The greater the length of the ' pencil lead,' the greater the resistance of the 'pencil lead'.*
- *Resistance of the 'pencil lead' is directly proportional to the length of the 'pencil lead'.*
- *Resistance of the 'pencil lead' is directly proportional to the length of the 'pencil lead' provided that the thickness, the type and the temperature are kept constant.*

Process skills:

- *Communicating science information*
- *Application of a formula i.e.proportionality*
- *Interpreting information.*

Acceptable minimum score: *3 out of 5*

Responses of learners to items 2.3 and 2.4

A possible reason for learners performing better on items 2.3 and 2.4 could be that, while being tested, a table was given to learners which indicated the variables that were being measured and calculated (Appendix 1). For the other items, however, learners had to understand the difference between an independent and dependent variable themselves in order to give the correct answer. Although the answers to items 2.3 and 2.4 produced higher mean scores compared to the other items in question 2, item 2.3 was noted to be an **ambiguous item** that could have puzzled some learners.

Quoted below are a few examples of strong and middle-of-the range learners' responses to item 2.3: "Which variables do they measure using meters?"

"The pencil lead".	*36% (middle)*
"Pencil lead and a ruler".	*45% (middle)*
"Length of wire and pencil".	*58% (strong)*
"Pencil lead".	*38% (middle)*

It seems that learners interpreted the measurement to be in meters, according to the way the question was asked. The question was badly phrased and displayed signs of ambiguity, from the word 'measure' onwards.

Responses of learners to item 2.6

The overall achievement score for item 2.6 had the third lowest mean value of 18% in that particular section, which was very low. This question required learners to write down the matter that needed to be investigated. The expected response was: *How is the resistance of 'pencil lead' affected by its length?* But, according to an experienced science educator and subject advisor, this is an ambiguous question:

> *"The word 'matter' is a very ambiguous one. It could rather have been written as 'what is the question they are trying to answer'. But most kids look at "matter" as being a physical thing and not an abstract thing".*

Learners' responses in the English group:

Commenting on item 2.6, one learner said:

> *"Whether or not pencil lead is a conductor of electricity".* *(38%)(middle)*

This was a common comment by the learners. It appeared that many of the learners interpreted item 2.6 as an answer to be given and not as an investigative question, which was required. The item was not clear enough and needed to be more specific by replacing 'matter' with 'question'.

Another learner commented:

> *"They are investigating how electricity and a circuit diagram works. They are investigating how little electricity you use, how cheap electricity is. How easily available electricity is".* *(61%)(strong)*

The ambiguity of the question was clearly reflected in this response. The learner seemed to think that he had to describe the question instead of responding in a scientific manner.

Learners' responses in the Xhosa Group:

> *"They investigated the method, the children plan an investigation that they use to show their knowledge and skills".* *(30%)(middle)*
>
> *"The electrician sets the meter to read current in amps and the other to read potential difference (voltage) in volts".* *(3%)(weak)*
>
> *"It's a battery, ammeter or voltmeter".* *(18%)(weak)*

Learners' responses in the Afrikaans Group:

> *"Dat die stroombaan aangaan en dit laat werk".* *(14%)(weak)*
> That the current continues and produces work.
>
> *"Hulle wil die weerstand hê".* *(40%)(middle)*

They want the resistance.

"Om te bewys dat lood (potlood) 'n geleir van elektrisiteit is".
To show that lead is a conductor of electricity. *(24%)(middle)*

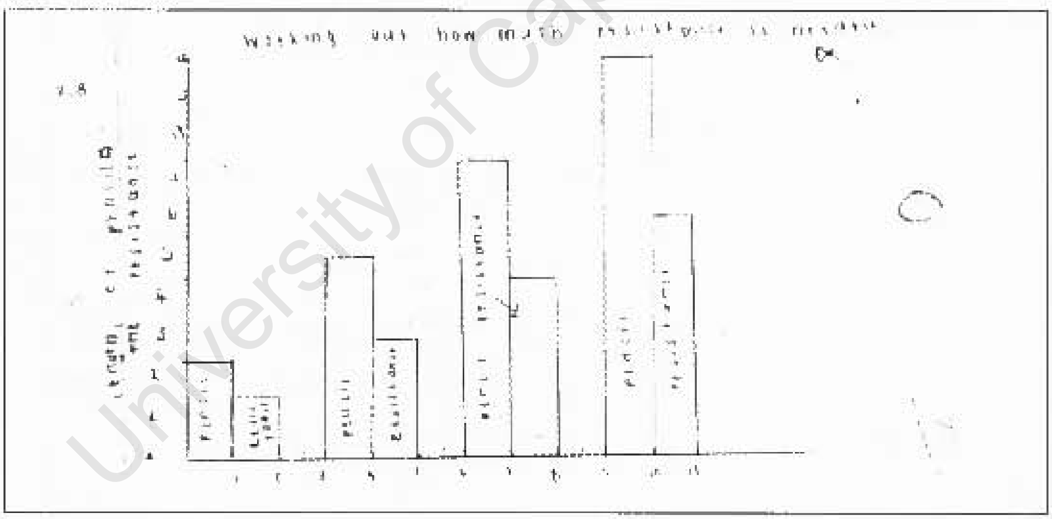
This ambiguity was also reflected in the Xhosa and Afrikaans groups.

<u>Responses of learners to item 2.8</u>

Learners' responses in the English group:

Figure 4.10 reproduces the response of a learner who appeared to have difficulty while presenting data using the appropriate graph. This kind of response has been quite common with a number of learners.

Figure 4.10: Example of a learner's incorrect display of data in response to item 2.8

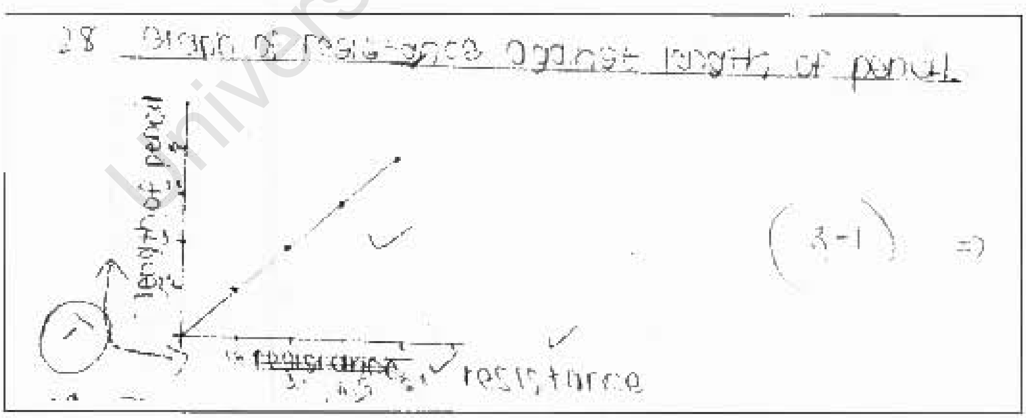


The presentation of data by using graphs is one of the process skills emphasised in the 'Resource Material' of the Natural Science Learning area (WCED, 2005) and the RNCS (DoE, 2002c). It is important that learners are competent enough to be able to give a good presentation of data.

After checking many scripts, a typical example of an inappropriate use of the bar graph has been selected and displayed in Figure 4.10 for this particular item 2.8. This learner's representation of data was scientifically incorrect and misleading. Firstly, on the CTA test paper, the unit of the pencil was given in centimetres and the unit of resistance was in ohms. These different units cannot be displayed correctly on the same axis as drawn by the learner in the above diagram. Secondly, the axes were not labelled by the learner, and the units on the horizontal axis as written by the learner are meaningless since they did not represent any form of data given in the table (Appendix 1). This learner (Figure 4.10) used the bar graph inappropriately. This is an example of the incorrect display of a composite bar graph where two sets of data are displayed on one graph (the pencil is presented in *cm* and the resistance in *ohms)* (Colyn, Hasson & Morrison, 2001).

Perhaps the mode of test instruction could have been worded more specifically. For example: "Draw a line graph of resistance against the length of the pencil lead included in the circuit" instead of: "Draw a graph……" (Figure 4.9). It seems from the above responses of learners that they did not know exactly what type of graph was appropriate to use when presenting certain data. However, the new curriculum requires learners to think more scientifically and this question required the learner to decide firstly on the choice of graph before drawing it, and then showing how it should be drawn.

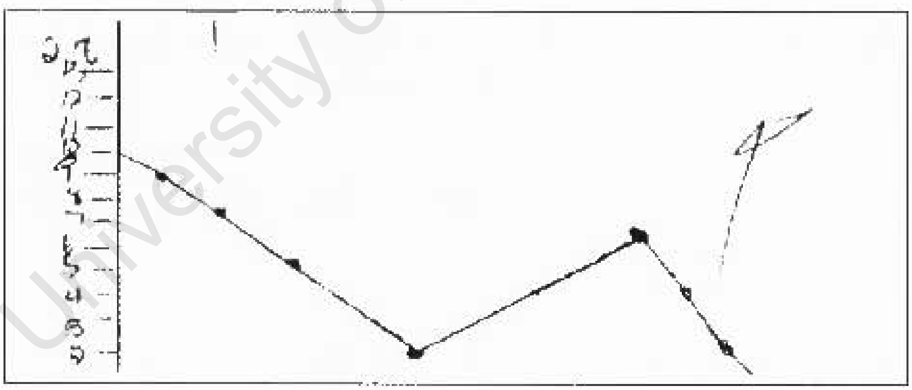
Figure 4.11: Example of the confusion by a learner of the terms 'dependent variable' and 'independent variable'



In Figure 4.11 it seems that when attempting item 2.8 the learner did not know the difference between the dependent and independent variable. Many learners could not deduce what label to put on the axes; for example, on the x-axis of the graph they often located the resistance instead of the length. These findings were consistent with those of Sadeck and Scholtz (2003) who used samples of first, second and third year pre-service science teachers at the Peninsula Technikon in the Western Cape. Earlier studies in England on 13-15-year-olds also revealed a low mean score in placing the correct variables on the correct axis (Schofield, 1989). A future follow-up interview with learners on how they understood variables might possibly produce a reason why learners under-performed.

One might have expected high values for the correlations calculated between the scores for the above items 2.2 and 2.8 and 2.5 and 2.8, since one would have expected that – if learners identified the variables – they would also know how to draw the line graph. Alternatively, if they had not identified the variables, they would not have known how to draw the graph. However, the occurrence of relatively low correlations of r=0.32 between the scores for items 2.2 and 2.8, and r=0.25 between the scores for items 2.5 and 2.8 seemed to indicate that some learners may have guessed the dependent and independent variables and that the answers in 2.2 and 2.5 were not necessarily consequential or complimentary to the item 2.8.

Figure 4.12: An example of incorrect plotting of points and incomplete labelling of axes in response to item 2.8



The learner whose work is featured in Figure 4.12 plotted the points incorrectly. The learner's plotting of points did not make sense since no labels were used for the axes. Instead of starting to plot from the top of the table, the learner started at the bottom. This immediately showed a negative slope which implied that the length of the pencil and its resistance were inversely proportional to each other, which was not the case in reality.

As the researcher, my impression is that, in future, a variety of examples should be given to learners during normal classroom lessons so that they can see and study relationships between two variables represented in tables, i.e. either inversely proportional to each other (as the length of the pencil lead increases, the resistance decreases) or directly proportional (as the length of the pencil lead increases, the resistance increases). As a mathematics and science teacher and researcher, I strongly believe that teachers should integrate more mathematics and science in their teaching. The link between the x- and y-values; the notions of independent and dependent variables; the concepts of inverse and direct proportion and the depiction of positive and negative graphs would most likely become less abstract to the learner. This kind of teaching practice was recommended long by Janvier (1978:14.22) who stated that "science and mathematics teachers should complement each other".

Responses of learners to item 2.9

Learners' response in the English group:

> *"The greater the length of the conductor (cm), the greater the electrical resistance (Ω) will be. Therefore, with an increase in length (cm), there is an increase in resistance (Ω)".* *(66%)(strong)*

This strong learner did not attain the full 5 marks because the anticipated conditions that type and thickness of the pencil should be kept constant were not specified in his or her answer. Many of the learners answered in this manner. Proportionality in the graph should have been recognised by the learners.

> *"The conclusion is that the longer the piece of lead used in the circuit the more resistance you end up with".* *(54%)(strong)*

> *"In conclusion, the pencil with the length of 10cm created the most resistance and the pencil with the length 2,5cm created 1,5 ohms of resistance making it the least of the pencils. The pencils with the length 5 and 7,5cm created resistance of 3 ohms and 4,5 ohms making them the middle amount. So, in conclusion, the pencil with the longest length creates the most resistance and a pencil with a shorter length creates less resistance".* *(60%)(strong)*

This strong learner wrote incorrectly about the length of the pencil instead of the length of the pencil lead. It seemed that this learner related the length of the 'pencil' to the resistance instead of the length of the actual 'pencil lead' itself. It might have been that this learner referred to the table supplied which had an incorrect heading along one of the columns (Appendix 1). The 'length of pencil in circuit' should have been 'length of pencil lead'. Diagrams with errors in labelling can cause confusion and misconceptions.

Learners' response in the Afrikaans group:

> *"Die gevoltrekking is dat Ampere sterker is as die volt 0.28".* *(21%)(weak*
> The conclusion is that the Ampere is greater in strength than the volt.

> *"Die kinders se gevolgtrekking is dat hulle hul ouers oortuig het dat dit kan werk en "x" kon toe vir "y" wys".* *(19%)(weak)*

> The children reached a conclusion that they convinced their parents and that "x" will show "y"

These are examples of some of the meaningless responses from learners. It seemed that these learners had little or no idea of what the question was about and it appeared that they simply wrote down anything.

> *"Die lengte van die potlood in n stroombaan was 2.5cm en sy weerstand was 1.5. Sit...0 cm potlood sy weerstand 3.0 en sit 7.5cm potlood sy weerstand 4.5 Ω en 10cm potlood is 6,0. Die stroomsterkte het elke keer groter met 1.5 gegaan".*

> The length of the pencil was 2.5cm and the resistance was 1.5. A 5cm pencil had a resistance of 3 Ω, a 7.5cm pencil had a resistance of 4.5 Ω and a 10cm length pencil had a resistance of 6 Ω. *(40%)(middle)*

This learner described the table instead of using it to draw a conclusion. Many learners answered in this manner.

Learners' response in the Xhosa group:

> *"They can multiply the symbols to find the conclusion".* *(10%)(weak)*
> *"They use pencil to add the circuit and they multiply the resistance and the ruler to do the circuit".* *(23%)(middle)*

These learners' responses did not make any sense. It seemed that they used multiplication because the question stated that they should use mathematical symbols.

> *"They reached how to use electricity".* *(15%)(weak)*

It seemed that this weak learner had difficulty understanding the question. It might possibly have been a language issue since the learner used "reached" incorrectly. The learner probably meant "learnt". Only 7% of the learners (140 out of 1572) attained 100% for item 2.9 (Table 4.2).

'Drawing a conclusion' involves number of skills, such as 'communicating science information' when learners report on an investigation. When answering this item, 'interpreting information' was also a skill with which learners were required to make inferences from given data. These particular skills are all categorized under medium level complex cognitive competences. The results indicate that the majority of learners have not reached the cognitive level and cannot therefore "relate two or more concepts" (Green & Naidoo, 2006). 'Application of knowledge' is recognised as another skill with which learners had to apply the formula of proportionality in item 2.9; i.e. in an electric circuit the magnitude of the resistance is proportional to the length of the lead in the pencil. Only 14% of the learners scored more than 50% for this question. Again, these findings were consistent with earlier studies reported on planning science investigations with Grade 7 learners (Hendricks, 1999).

The scores of the learners' responses to item 2.8 and 2.9 correlated r=0.60 which gave a fair indication that the learners who performed well in item 2.8 tended to perform well in item 2.9, and vice versa. This suggested that learners who knew how to draw the graph in item 2.8 may have seen a relationship between the length of the pencil lead and the magnitude of its resistance, and thereby have drawn a conclusion. However, if they did not get item 2.8 correct, it was likely that they got 2.9 incorrect as well.

It seemed that the overall performance of learners on Question 2 was grossly inadequate compared to their achievements on the other questions. This question involved mainly the skill of "identifying variables". Studies conducted on the performance of certain process skills with Jamaican Grade 9 and 10 learners corroborated these findings (Beaumont-Walters & Soyibo, 2001). Voltage was not mentioned specifically in the Grade 9 Revised National Curriculum Statement (DoE 2002c) but it has been referred to in the Grade 10 syllabus. Although the new curriculum places emphasis on skills and application of knowledge, and attitudes and values, teachers should have sufficient guidance on which concepts to teach and to what extent. For example, the electricity section should have specific concepts outlined, i.e. 'battery', 'cell', 'parallel', 'series', etc. In this manner all schools would have a common minimum requirement outlined for them in Grade 9 and this could possibly develop consistency among schools.

4.3.5 Learners' achievement on CTA Question 3 (Topic: Wetlands)

Research sub-question No.1 on page 97 will now be answered and discussed for the learners' achievements on CTA Question 3.

For CTA Question 3, it was found that, for the combined sample of 1572 learners taken as a whole, acceptable levels of achievement were attained only on items 3.2 and 3.4, but not on items 3.1 and 3.3 for which less than half of the learners achieved the acceptable level, as recorded in Table 4.3.

Table 4.3: Basic descriptive statistics for the performance scores of the combined sample of learners on Question 3 of Section B in the 2004 Grade 9 CTA in Natural Science (n = 1572)

CTA item No.	Content of the item	Mean ± SD	Mean Score (%)	Possible scores	Acceptable minimum score	f (%)
3.1	Give four reasons for preserving wetlands.	3.40 ± 2.63	57%	0 1 2 3 4 5 6 7 8	4	311 (19.8%) 146 (9.3%) 205 (13.0%) 173 (11.0%) 233 (14.8%) 97 (6.2%) 179 (11.4%) 48 (3.1%) 180 (11.5%)
3.2	Give four more problems threatening this wetland.	1.79 ± 1.32	60%	0 1 2 3 4	2	334 (21.3%) 353 (22.5%) 397 (25.3%) 280 (17.8%) 208 (13.2%)
3.3	Choose one of the problems in 3.2 and list three (or more) steps that should be taken to solve the problem.	1.46 ± 1.11	49%	0 1 2 3	2	412 (26.2%) 395 (25.1%) 399 (25.4%) 366 (23.3%)

Table 4.3 (continued)

CTA item No.	Content of the item	Mean ± SD	Mean Score (%)	Possible scores	Acceptable minimum score	f (%)
3.4	There are eight people taking part in the conversation about the wetland above. Read their opinions and decide with which one of the people you agree most. Identify that person and then describe, in about two or three sentences, why you agree with their argument.	2.63 ± 1.62	53%	0 1 2 3 4 5	3	153 (9.7%) 328 (20.9%) 276 (17.6%) 295 (18.8%) 232 (14.8%) 288 (18.3%)

Mean = average score
SD = standard deviation
f = frequency of the score
(%) = the percentage of the sample obtaining a particular score

CTA Question 3 focused on the assessment of LO2 and LO3. The skills tested were 'problem solving' and 'interpreting information' given about wetlands. This question specifically dealt with sustainability with regard to the wetlands and the environment.

The majority of learners had difficulty answering items 3.1 and 3.3. Satisfactory performance on item 3.1 demonstrated the attainment of LO2 where the learner has to recall meaningful information on wetlands (see Figure 4.13 on page 128). Item 3.3 assessed LO3 where the learner has to use problem solving skills. Although 'recalling information' based on wetlands had been identified as a skill, learners were supplied with sufficient information via text and illustration to answer the questions adequately. This question 3 referred more to the skill of 'translating diagrams into text' as opposed to 'recalling prior knowledge'. Whereas traditional education has placed a high value on the learner knowing answers to standard questions, through rote learning – which, according to Verhage and DeLange (1997), is the lowest level of competence – the Revised National Curriculum Statement has also placed stress on the learner being able to solve problems and think of ethical alternatives (DoE, 2002c) – which is regarded as a higher competence level. Despite the illustrations given to learners in the CTA, it seemed that many learners could not gather sufficient evidence from the text to substantiate their arguments for having a wetland. Possible reasons for their inadequate performance will be identified in the interviews with learners and teachers.

4.3.6 Learners' misconceptions on CTA Question 3

Research sub-question No. 2 asked:

"Were the learners' misconceptions in knowledge and skills found to be similar to those already known in the published literature; and did there appear to be any misinterpretations of certain questions when representative samples of English-speaking, Afrikaans-speaking and Xhosa-speaking learners had their CTA answers scrutinized in depth through interviews with teachers and learners, as well as on their scripts?"

This research sub-question will now be answered, analysed and discussed for CTA items 3.1 to 3.4.

Figure 4.13 reproduces the presentation of CTA item 3.1 to 3.4 and it supplies the memorandum of expected correct answers and responses.

Figure 4.13: CTA items 3.1 to 3.4 and their expected responses

Item 3.1: *Give four reasons for preserving wetlands. The reasons you give should make clear your understanding of what a wetland is.*

Expected responses:

- *Wetlands are water traps that help prevent flooding.*
- *Places that maintain biodiversity; or preserve: plants, birds, fish, animals specific to the wetland environment.*
- *Provide unique types of recreational activities; or hiking, bird watching, fishing, boating.*
- *A source of unique products – e.g. sedges; baskets, mats, house building material, any other correct answer.*
- *Economic activity; or mats, baskets, fishing, tourism, medicines, any other correct answer.*
- *Food source; or plants, animals, fish, any other correct answer.*
- *Culturally related activities; or reed dance, medicine, any other correct answer.*

Process skills:

- *Recall meaningful information*
- *Interpreting information*
- *Problem solving.*

Acceptable minimum score: *4 out of 8*

Item 3.2: *One way we can describe the underlying problem which makes people a threat to this wetland is the need people have for land, water and shelter. Give four more problems threatening this wetland.*

Expected responses:

- *Chemical pollution.*
- *Contamination with nitrogen rich fertilizers.*
- *Contamination with pesticides.*
- *Invasion by exotic plants.*
- *Invasion by animals.*
- *The draining of the wetland – need for jobs and increasing industrial output; also increases use of water by industry, which already uses more water than agriculture.*
- *The draining of the wetland – need for increased food production, a need for more farming; a need for more water and increased irrigation; creates a threat to drain the wetland of its water.*
- *Biological pollution.*
- *Invasion by humans – possibility that the wetland can be overrun by fisherman, boatman, birdwatchers,...*

Process skills:

- *Recall meaningful information*
- *Interpreting information*
- *Application of knowledge*
- *Problem solving.*

Acceptable minimum score: *2 out of 4*

Item 3.3: *Choose one of the underlying problems that you gave in the answer to part 3.2 and list three (or more) steps that you believe should be taken to solve the problem.*

Expected responses:

- *Law : ensure that there are laws in place to stop dumping of waste of any kind into wetland. this includes certain pesticides by farmers.*
- *Policing: Need for policing to enforce the laws.*
- *Resources to police - a programme of ongoing water testing for chemical and biological contamination as well as water quality; on site inspections to ensure no dumping.*
- *Prevention: Need for chemical plants to remove chemical impurities and for biological purification to treat plant and animal waste so that they do not get into he water in the first place.*
- *Education: Change people's attitudes – provide information and encourage responsible use of wetlands by industrialists.*
- *Any other.*

Process skills:

- *Application of knowledge*
- *Problem solving.*

Acceptable minimum score: *2 out of 3*

Item 3.4: *There are eight people taking part in the conversation about the wetland above. Read their opinions and decide with which one of the people you agree most. Identify that person (e.g. farm community leader,.....) and then describe, in about two or three sentences, why you agree with their argument.*

Expected responses:

This answer is worth 5/5

- *Persons with whom I agree most: Officials from DEA.*
- *Reasons for agreeing with officials from the DEA.*
- *Sustainable development is the key – long term.*
- *Most people come out winners – it is a sensible compromise.*

Other possible responses:

- *Only the proposer, and is short term (e.g. farmer; community leader) (0-1mark)*
- *The proposer and one or two more and is short term (e.g. business woman, mother) (2marks)*
- *The proposer and one or two more and has long term possibilities (e.g.birdwatcher)(3marks)*
- *Many different interest groups and is really long term (e.g. DEA official) (4-5 marks).*

Process skills:

- *Interpreting information*
- *Justifying an argument.*

Acceptable minimum score: *3 out of 5*

A number of alternative answers and variant response to items 3.1 and 3.3 were noted in the learners' scripts. These are recorded verbatim and discussed below.

The majority of learners who achieved a fairly good mark (i.e. above 50%), answered Question 3 adequately. Therefore I will concentrate on the learners who attained lower scores.

Item 3.1 was presented in two parts (see figure 4.13). The reasons given by learners had to reveal a clear understanding of what a wetland is.

Learners' responses in the English group: Item 3.1 (see Figure 4.13 on page 129)

Four reasons offered by one learner were:

> *"So it does not get polluted".*
> *"So it can attract animals and birds".*
> *"To protect children".*
> *"To attract tourist".*

(25%)(middle)

The reasons given by this average learner indicated only to a certain extent whether or not he or she had understood what a wetland was. "To protect children" was given in the learner's answer as a reason to dry up the wetland instead of preserving it (Appendix 1). It seemed that the learner could not use the picture and text illustrations together successfully, as intended by the examiner, to answer the question completely.

According to Duchastel (1983:4), illustrations serve to "enhance comprehension, and reinforce the argument in the verbal part of the text in order to assist the reader in understanding the message." Although the CTA examiner presented the illustrations accompanied by "talking heads" to provide the learner with a better understanding, it seemed that most learners had difficulty interpreting the illustration as the examiner intended. Another reason could have been that learners experienced an increase in "memory load" from the text and illustrations given (Gobert & Clement, 1999:40).

Learners' responses in the Afrikaans group: Item 3.1

Two learners responded as follows:-

> *"Die kinders kan baie siek raak".*
> *" Dit is vuil water".*
> *" Die kinders kan seer kry".*
> *"Die diere kan dood gaan".*

(53%)(middle)

> The children can get very sick.
> It is dirty water.
> The children can hurt themselves.
> The animals will die.

" klamigheid"
" siektes"
"ruim"
"water"

(19%)(weak)

dampness
sickness
empty
water.

It appears that these learners also misinterpreted the question, and their reasons for preserving the wetlands were not clear enough.

From the above responses there was evidence that language, skill of expressing themselves and comprehension skills may have been factors that influenced the learners' ability to answer correctly. According to Ramsden (1998) and Osborne and Collins (2001), (cited in Bennett 2003), writing was viewed as the least liked activity in science lessons because it required added linguistic skills that demanded learners to express themselves more clearly. In science this problem was exaggerated by the conventional use of a certain scientific language that entailed "impersonal language in reporting" (Bennett, 2003:166).

Learners' responses in the Xhosa group: Item 3.1

"The children are not safe near the wetland".
"They always seem to be ill".
"The wetland is smelly because of the pollution".
"Air pollution from the factories".

(36%)(middle)

It seemed that this learner may have misinterpreted the question. The learner appeared to have used the picture of the wetland and described it as a hazardous situation, instead of giving reasons to preserve it as a valuable asset. In this instance, it seemed that this response could possibly have indicated a language issue, when a learner who used English as a second language struggled to interpret the question correctly.

Another learner wrote:-

"The wetland they must drain because of illing children".
"The wetland they must drain because of the farmers must get some more land to plant for people".
"The wetland must drain because pollution come with different way".

(19%)(weak)

This academically weak learner misunderstood the question completely. The learner appeared to experience difficulty comprehending the question, and it seemed possible that language may have been a contributing factor. This was detected from the learner's use of incorrect grammar. Perhaps the learner did not understand the meaning of the word "preserve" and interpreted it as "getting rid of the wetland".

4.3.7 Learners' achievement on CTA Question 4 (Topic: Chemistry)

Research sub-question No.1 on page 97 will now be answered and discussed for the learners' achievement on CTA Question 4.

For CTA Question 4, it was found that, for the combined sample of 1572 learners taken as a whole, acceptable levels of achievement were attained only on items 4.1(a), 4.2(b)1 and 4.2 (b)2; but not on items 4.1(b), 4.1(c), 4.2(a) and 4.2 (b)3; for which fewer than 50% of learners achieved the acceptable level, as recorded in Table 4.4.

Table 4.4 presents the overall performance details for the combined sample on CTA Question 4.

Table 4.4: Basic descriptive statistics for the performance scores of the combined sample of learners on Question 4 of Section B in the 2004 Grade 9 CTA in Natural Science (n = 1572)

Item	Question	Mean ± SD	Mean score %	Possible scores	Acceptable minimum score	f (%)
4.1(a)	Study the following diagrams representing 3 different types and numbers of molecules (A, B and C). Use the key in the above diagram and give a formula for each.	1.98 ± 1.39	50%	N/A 0 1 2 3 4	2	96 (6.1%) 239 (15.2%) 244 (15.5%) 407 (25.9%) 294 (18.7%) 292 (18.6%)
4.1(b)	Use the key with the diagram and write down a balanced equation for the reaction that occurs when ethane burns.	1.01 ± 1.59	25%	N/A 0 1 2 3 4	2	121 (7.7%) 953 (60.6%) 49 (3.1%) 88 (5.6%) 90 (5.7%) 271 (17.3%)
4.1(c)	Balance the following equation.	0.39 ± 0.72	20%	N/A 0 1 2	1	124 (7.9%) 1055 (67.1%) 175 (11.1%) 218 (13.9%)
4.2(a)	Use the information in the graph to draw up a table giving the information conveyed by the graph.	1.58 ± 1.50	40%	N/A 0 1 2 3 4	2	126 (8.0%) 475 (30.2%) 188 (12%) 284 (18.1%) 265 (16.9%) 234 (14.9%)
4.2(b)1	List one advantage and one disadvantage for the children's family of using wood.	1.09 ± 0.87	55%	N/A 0 1 2	1	126 (8.0%) 408 (26%) 360 (23%) 678 (43.2%)

Table 4.4 (continued)

Item	Question	Mean ± SD	Mean score %	Possible scores	Acceptable minimum score	f (%)
4.2(b)2	List one advantage and one disadvantage for the children's family of using propane gas.	0.98 ± 0.90	49%	N/A 0 1 2	1	127 (8.1%) 525 (33.4%) 303 (19.2%) 617 (39.3%)
4.2(b)3	List one more advantage or disadvantage for the family of using wood or propane.	0.42 ± 0.49	42%	N/A 0 1	1	127 (8.0%) 806 (51.3%) 639 (41.9%)

Mean = average score
SD = standard deviation
f = frequency of the score
(%) = the percentage of the sample obtaining a particular score

Items 4.1(a) – 4.1(c) tested the learners' ability to achieve learning outcome 2 (LO2) (constructing science knowledge). The skills tested were 'interpreting information'; 'recalling information' and 'application of knowledge' (Appendix 2). Question 4 linked with the section in the chemistry syllabus on balancing equations. This section was taught in grade 9, and it was assumed that learners already had an adequate prior knowledge relating to this topic. However, what was tested in the CTA was a skill in 'interpreting diagrams and illustrations' and not necessarily content. In order to answer this question, prior knowledge of chemistry at the atomic/molecular level could be considered highly relevant (e.g. Gabel, Samuel & Huhn, 1987; Gabel, 1993). According to Nurrenbem and Pickering (1987), this prior knowledge of chemistry at the atomic/molecular level is a major tool to enable conceptual understanding in chemistry.

In general, students' familiarization with the microscopic level of description does not prove to be easy due to the difficulty of perceiving invisible entities as concrete objects and of dealing with them accordingly. Imagery can prove to be a powerful tool to facilitate this familiarization. In Italy learners and teachers found the use of imagery to be very attractive and helpful when presented alongside the text (Mammino 1994, cited in Mammino 2002:237). Direct experience with students in another context (Italy) showed that an approach involving a systematic use of imagery

- by offering an explanation through imagery parallel and complementary to that of the text - received particular favour among chemistry teachers and encouraged students to perceive chemistry as "attractive".

It seemed possible that in 2004 the CTA examiner tried to present the combustion of gases and chemical reactions as realistically as possible, but this depiction generated mixed feelings from teachers at different schools when they were interviewed (see Section 4.4.4 on page 149).

To utilise different forms of gases, the CTA test setter selected the examples of methane and propane (given earlier in CTA Section A). These kinds of gases are classified as alkanes and - in both the past and at present – currently they are taught later only in Grade 11 and Grade 12 under the section on organic chemistry. All of these CTA items 4.1(a) to 4.1(c) used imagery to represent the different atoms and molecules. Learners were required to interpret the diagrams given, then to develop a formula and balance an equation. This question displayed a good example of the use of chemistry and balancing equations in everyday life. Although it can be argued that it cannot always be possible to provide everyday life examples – it may make the lesson more exciting and interesting. However, assessment tasks set in "real life" contexts disadvantaged working class learners (Cooper & Dunne, 1998).

The performance results of the 1572 learners on item 4.1(a) were somewhat different from the findings reported by Mammino (2002) at the University of Venda, when first year chemistry students had to write the formulae of a few molecular structures drawn on the board. Although the mean score in the Western Cape for this Grade 9 CTA item was 50%, only 19% of the 1572 learners in the current study managed to write the formula correctly. A possible explanation for this could have been the ages in my own sample ranged from 14 – 15 years when compared to the Venda study done with first year university students, who were probably 18 to 20-year-olds who seemed to perform better in exercises using imagery to write a formula. However, the students in the Venda study performed poorly when they had to draw ball and stick models of selected molecules on the basis of the formula (i.e. representing the chemical formulae using sketches).

It would have been interesting to know how the Grade 9 learners might have performed in a similar exercise in Section A if they had been asked to represent the chemical formulae using sketches. This particular approach to teaching chemistry should possibly be required in the teaching of basic chemistry at the Grade 9 level, since some Grade 9 textbooks - such as Study and Master (van Zyl, *et al.*, 2001) - which contain no visual representations of atoms or molecules and their combinations – tend to prompt teachers to rush into a particularly abstract approach to chemistry. Instead chemistry teachers might be guided in the future to teach more in this manner using visual presentations, since these current (CTA) attainments were not very successful.

According to Mammino (2002:237), visual presentations express perceptions and mental images about the object concerned, and they also prove to be a powerful tool to elicit learners' misconceptions about the two fundamental issues of chemistry: "*how molecules are made* and *what molecules do*".

In this current CTA study, it was difficult to attain a complete quantitative evaluation of the extent to which utilisation affected the learners' understanding and acquisition of knowledge. Nevertheless, it appeared that the majority of learners either had never grasped the skill of using the given diagrams to balance the equation, or they had not been given sufficient examples and exercises to do in class, according to the findings for items 4.1(a) and 4.1(b). More research might be done to ascertain if this is indeed so.

Despite the information given in item 4.1, the learners' performances on question 4 as a whole were inadequate, although item 4.1(a) had a reasonably acceptable mean score of 50%. It seemed that learners had particular difficulty answering items 4.1(b) and 4.1(c). In item 4.1(b), the learners were expected to write down a balanced equation for the reaction that occurs when ethane burns, using the given key and diagram. The learners in their classes should have attempted a similar exercise in Section A in the preceding weeks, and therefore should have been familiar with this particular skill. Nevertheless, 8% of the learners did not respond at all. Either they ran out of time or they had no idea how to answer the question. Only 17% answered correctly and 61% scored zero which was an alerting finding in relation to classroom pedagogy, learners' understanding of the skill and learners' interpretation of the imagery used in chemistry.

Perhaps too few practice examples had been given to learners in classroom lessons prior to formal testing, which could have resulted in their poor standardized CTA performance.

Item 4.1(c) presented a question on balancing an equation. Although no diagrams were supplied to assist the learners, the learners should have acquired enough prior knowledge in their classroom chemistry lessons to have been able to answer the question correctly. For item 4.1(c), only one quarter of learners achieved 50% and above. Two thirds of the learners obtained 0%. This was something for high school science educators to be concerned about, since the teaching and understanding of basic chemistry is fundamental for promoting future scientists. Grade 9 remains a crucial year for learners when subject choices are made, not only on the basis of their performance during the year, but also based on their impression of the school's own introductions to chemistry and physics courses.

For some time, it has been argued that content-led teaching can be unsuccessful in terms of learners not being able to apply their new knowledge in familiar contexts (Simpson 1987, cited in Wellington, 1989). This view has been supported by Wellington (1989) who believed that skills could be transferred into different contexts and are therefore more relevant than content knowledge. However, I do believe that content and skills are difficult to separate as expressed by Ogunniyi (1999). Hence, it can be suggested that enough time should be given for learners to grasp a particular skill and its different contexts in order to be able to apply the knowledge. If the aim of the new curriculum is to teach learners to use certain skills successfully, then my impression is that everyday applications of certain skills might be made more specific for teachers, by giving examples, so that learners can become more familiar with the practical relevance of skills required. In CTA Section B it seemed that most learners could not independently apply the knowledge recently taught to them in CTA Section A in previous lessons, either because they had not been taught it thoroughly enough or because they had not been given enough time to grasp it in class.

4.3.8 Learners' misconceptions on CTA Question 4

Research sub-question no. 2 asked:

"Were the learners' misconceptions in knowledge and skills found to be similar to those already known in the published literature, and did there appear to be any misinterpretations of certain questions when representative samples of English-speaking, Afrikaans-speaking and Xhosa-speaking learners had their CTA answers scrutinized in depth through interviews with teachers and learners, as well as on their scripts?"

This research sub-question will now be answered, analysed and discussed for CTA items 4.1(a) to 4.2(b)3.

Appendix 1 reproduces the textual presentation of CTA items 4.1(a) to 4.2(b)3. It also supplies the memorandum of expected correct answers and responses.

A number of alternative answers and variant response to items 4.1(a) were noted in the learners' scripts. These are recorded verbatim and discussed below.

Figure 4.14 reproduces the most common answer given by learners for the chemical formula sought for each molecular diagram presented in the CTA item 4.1(a).

Figure 4.14: Example of a learner's incorrect representation of a water molecule (the middle response)

O_2	O_3H_6	C_2H_6

The learner whose response is depicted in Figure 4.14 gave the correct formula for oxygen (on the left hand side) and methane (on the right hand side) but wrote an incorrect representation for the water molecule (in the centre). After inspecting their scripts it became apparent to the researcher that many learners either had no idea of the standard formula for water or they believed that each substance had a particular formula that cannot be modified. A previous study also disclosed that many first year chemistry students at the University of Venda also failed to realise that the water molecule has a standard formula of H_2O and that only the coefficient of the written formula can be changed, e.g. $3H_2O$ or $4H_2O$ etc. (Mammino, 2002). This implies that more concrete examples and exercises, like visual representations of molecules, might have to be given to learners in future to make clear the "law of definite proportions" - which means that each substance has its own formula that cannot be modified but that the number of molecules can be changed.

In the reproduction depicted in Figure 4.15 the learner gave the formulae for the oxygen molecule and the water molecule correctly but either seemed to misinterpret the diagram of the ethane molecule (on the right) or did not realise that there was a bond between the two carbon atoms, thus: CH_3 - CH_3.

Figure 4.15: A learner's incorrect formula for an ethane molecule (right hand side answer)

O_2	$3H_2O$	$2CH_3$

The learner in Figure 4.15 apparently saw two molecules of methane (CH_4) instead of one molecule of ethane (C_2H_6). It seems that the learner did not understand that the two carbon atoms were bonded together and therefore it is one molecule of ethane instead of two molecules of methane as incorrectly indicated in the answer. If the learner had sufficient time to complete CTA science paper section A - which had similar examples - and if the teacher had gone over the exercise with the learners to apply formative assessment effectively, then perhaps the learner in Figure 4.15 would have been better able to give the correct formula.

Another learner whose answer is reproduced in Figure 4.16, had not developed the skill of translating a visual representation of molecules into the correct chemical formula.

Figure 4.16: Reproduction of a learner's faulty attempts to compose molecular formulae for three molecular diagrams

A = 2O	B =3O + 6H	C = 2C + 6H

It appears that the learner whose attempts are reproduced in Figure 4.16 merely added the different number of atoms together instead of producing the formula required for each molecule.

These responses from learners supplied enough evidence to indicate that some learners had problems with chemical formulae. However, a further interview with learners will establish whether other factors may also have influenced their performances.

Items 4.2(a) – 4.2(b)3 tested the learners' ability to achieve Learning Outcome 1 (LO1: scientific investigations) and Learning Outcome 2 (LO2: constructing scientific knowledge). The skills tested were 'interpreting information' from straight line graphs and 'communicating science information' (Appendix 2).

For item 4.2(a), learners were required to draw up a table using the information conveyed by the graph. Only 15% of the learners attained full marks, with 42% appreciably underachieving. After scrutinising many scripts, the problems that became evident were: difficulty in reading off the appropriate dot on the graph; and incomplete labelling of the table, resulting in a meaningless interpretation of data. These findings suggested that perhaps the skill of translating a graph to a table had not been practised sufficiently in many classes.

In future, although this particular skill (tabulating a graph) is mentioned in the policy document (DoE, 2002c), either science teachers could be given examples to use from a particular textbook, or additional examples could be developed by science teachers themselves. There is evidence to suggest that teachers may need specific practical guidance, not mere policy documents, since there are various factors that could affect the proper teaching of these skills. For example, currently many Grade 9 teachers teach more than one subject; their classes are big; they have burdensome loads of administrative work; they may have appreciable discipline problems to deal with; typically they have onerous marking and deadlines to meet; and many teachers are teaching Natural Science without an adequate background in the content of science themselves (White, 2003).

A number of alternative answers and variant responses to item 4.2(a) were noted in the learners' scripts, and those also became apparent during the recorded interviews. Figure 4.17, for example, reproduces a 15-year-old's incorrect reading of points from the graph in response to item 4.2(a).

Figure 4.17: A learner's response to item 4.2(a) showing an incorrect display of points from the graph

Type of fuel	Mass used (kg)	Energy produced (kWh)
wood	0,0kg	1kWh
coal	0,13kg	1kWh
propane	0,4kg	1kWh

This photocopied reproduction was a typical example of the problems that learners encountered when reading off points from a graph. The correct reading required for the propane value was 0.08 but the learner gave it as 0.4. It appeared that this learner could not see a difference of 0.02 between each block. It might be said that this misconception could be attributed as well to the learner's possibly limited conceptual understanding of the symbolic representations of decimals. It seemed that the learner focused on giving the correct answer without checking or verifying whether it was logical or not. It appeared that some learners had definite problems interpreting points on graphs. One wonders whether the decimal values displayed on the vertical axis confused some of the learners. This difficulty in interpreting points from a graph was also noted in a study by White (2003) who found that most learners gave the incorrect reading from the line graph. It appeared that the teachers in White's study also experienced difficulty in scaling and interpreting graphs. Although this present study did not investigate teachers' ability to teach the process skills, one wonders whether a possible lack of teacher expertise in teaching line graphs and scaling was a factor that subsequently hindered the learners' performance in interpreting line graphs.

Figure 4.18 reproduces how one learner incorrectly drew a graph instead of a table in response to item 4.2(a). Previous studies also reported learners incorrectly drawing a bar graph instead of a table (Sadeck & Scholtz, 2003).

Figure 4.18: A learner's reproduced response to item 4.2(a) showing an incorrect display of data

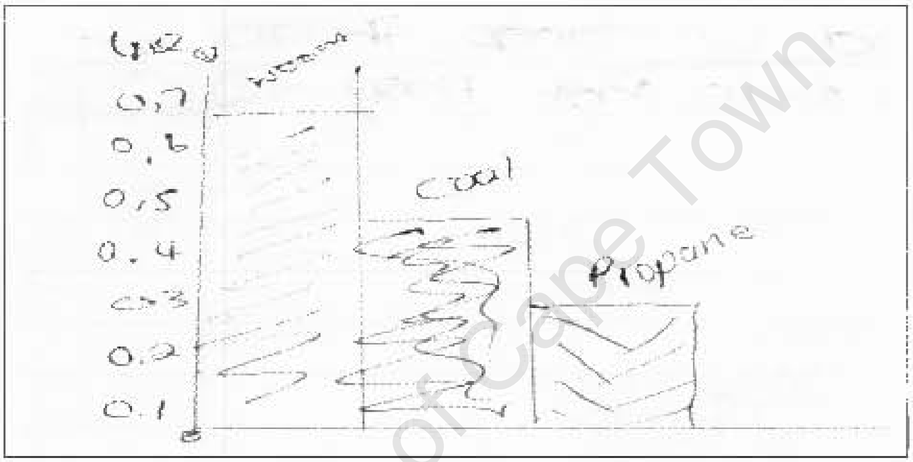
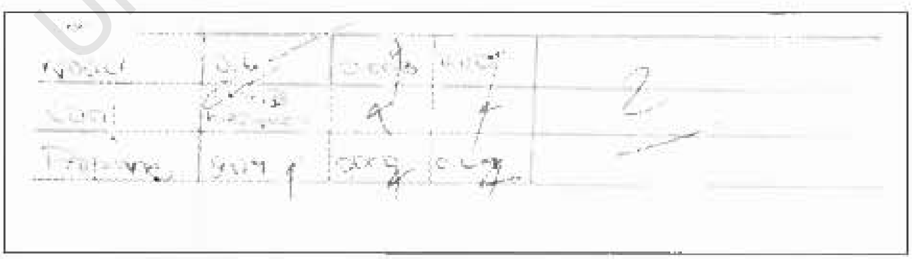


Figure 4.19 depicts another learner's effort in response to item 4.2(a).

Figure 4.19: A learner's reproduced response to item 4.2(a) showing an incomplete table



In this example the learner did not give appropriate headings to the table, nor to the columns. These errors corroborated the findings of a previous study at the Bellville Peninsula Technikon in which it was found that very few learners had labelled such columns (Sadeck & Scholtz, 2003). The data displayed by the learner in Figure 4.19 does not make any sense and the values are incorrect. Once again the learner whose work is reproduced in Figure 4.19 had read off the points incorrectly.

Overall analysis of the learners' graphical representations in items 4.2(b)1 to 4.2(b)3

It seems possible that many learners failed to respond to these items because they had run out of time. Although the mean values were not as low as found for some of the other items - for example, items in Question 2 - there were many learners who scored zero, especially for item 4.2(b)3 for which 51% scored zero. When learners were interviewed, many of them said that they found the line graphs difficult to interpret.

4.3.9 Learners' achievement on CTA Question 5 (Topic: Graphs)

Research sub-question No.1 on page 97 will now be answered and discussed for the learners' achievements on CTA Question 5.

Appendix 2 reproduces the textual presentation of CTA Question 5. It also supplies the memorandum of expected correct answers and responses.

It was found that, for the combined sample of 1572 learners taken as a whole, the majority of learners underperformed, and only 32% of learners met the acceptable level of achievement by scoring 50% and above.

Table 4.5 presents the overall performance details for the combined sample for CTA Question 5.

Table 4.5: Basic descriptive statistics for the performance scores of the combined sample of learners on Question 5 of Section B in the 2004 Grade 9 CTA in Natural Science (N = 1572)

Question no.	Question	Mean ± SD	Mean score %	Possible scores	Acceptable minimum score	F (%)
5	Explain the influence of the rainfall in 2003/2004 on the bird population in particular, and on the whole ecosystem in general.	1.73 ± 1.71	28%	N/A		127 (8.0%)
				0		428 (27.3%)
				1		259 (16.5%)
				2		255 (16.2%)
				3	3	216 (13.8%)
				4		164 (10.4%)
				5		91 (5.8%)
				6		32 (2.0%)

Mean = average score
SD = standard deviation
f = frequency of the score
(%) = the percentage of the sample obtaining a particular score

Question 5 tested the learners' abilities to achieve Learning Outcome 1 (LO1) (scientific investigations), Learning Outcome 2 (LO2) (constructing science knowledge) and Learning Outcome 3 (LO3) (science, society and the environment). The process skills tested were 'interpreting information', 'communicating science information' and 'inferring'.

In this question, 32% of learners could at least interpret the three graphs, but they were unable to draw conclusions; and only 2% scored 6 out of 6.

According to the rubric for CTA item 5 (Appendix 1), only 18% of learners could make a plausible link between two of the graphs. This finding is of concern since interpreting graphs and making inferences is very much part of the attainment of Learning Outcome 2 (LO2: constructing scientific knowledge).

4.3.10 Learners' performances on CTA Question 5

In this particular question, learners were required to interpret information by translating line graphs and a bar graph into text descriptions, and to describe the relationship between variables and the effect of one variable on the other. Graphs and diagrams are abstract spatial representations (Hegarty, Carpenter & Just, 1991). However, graphs differ from diagrams because they illustrate relationships among variables, whereas diagrams describe processes and structures (Winn 1987:165).

This CTA exercise presented the learners with diagrammatic, graphic and pictorial illustrations combined with text. The learners faired better at interpreting the picture illustration representations with combined text, i.e. question 3, when compared to their performances in the diagrammatic representations (items 4.1a, 4.1b) and graphic representations (items 4.2b1, 4.2b2, 4.2b3 and 5). However, in view of the small number of questions presented in the diagrammatic presentations and the larger range in the graphic and pictorial illustrations, the patterns of the overall scores pertaining to these items must be interpreted with caution.

Also, a factor that may have influenced these results was that some learners answered none of the latter items, most likely because of a limited time constraint. However, it does seem that the graphs proved to be more complex representations for the learners - as many of them mentioned in the interviews – since their insights into the relationships between variables were tested in these types of questions in particular. When interviewed, learners said that they found the bar graphs to be the easiest to interpret, which corroborated other authors' views (White, 2003).

4.4 A critique of the presentation of the test designer's format and presentation of the 25 items in the CTA

Research sub-question No. 3(a) asked:

"Did the in-depth interviews conducted with the selected teachers and learners reveal possible short-comings in the wording and composition of each one of the items 1 to 5 (e.g. in respect to clarity, length, layout, degree of abstraction, sequencing, weighting, appropriateness for RNCS 2002, ambiguity and diagrammatic representation)?"

Research sub-question No. 3(b) asked:

"Did the in-depth interviews produce triangulating evidence that clearly illuminated, explained, corroborated or amplified the empirical findings presented as answers to the research sub-questions 1 and 2?"

The answers to Research sub-question No.3(a) and 3(b) are presented and discussed as follows:

4.4.1 Critique of CTA item 1.4

This item tested skills in interpreting information, observing, comparing and decision making which refer to more middle level, complex cognitive competences (Green & Naidoo, 2006).

The outcomes tested were LO1 and LO3.

When interviewed on the appropriateness of the wording and composition of CTA item 1.4, Teacher A said:

> *"The question on how the father should use their money - I think it is a lot to ask of a child as to how their father should be budgeting and really it is very difficult to give anything other than 5 marks because it is their opinion which, by definition, can't be wrong. I think it was very open-ended and not enough guidance as to what exactly the student should do".*

This question (item 1.4) prompted learners to think deeply about a situation and encouraged decision making with regard to a situation. It reflected what had been specified in the curriculum:

> Teachers are encouraged to view the remaining 30% of the time as available for extending the core and for curriculum development around contexts which are significant to learners and the local community. These may be economic, environmental, social or health contexts.
> (DoE 2002c:7).

I agree to some extent with the teacher's comment that it was an open-ended question, but I believe that it encouraged many learners to demonstrate their attainment of outcomes in issues which had relevance to their lives, as mentioned in the Natural Science policy document (DoE, 2002c:7). Therefore it could not be regarded as an unfair question in the light of the policies of the new revised curriculum. However, the teacher's response implies that these open-ended contextually designed questions are not very explicit and they also require learners to read, absorb and respond. Studies elsewhere have also shown that learners seem to struggle with these types of contextually designed questions (Bansilal, 2008; Boaler, 2003; Cooper & Dunne, 1998).

4.4.2 Critique of CTA item 3.1

When interviewed on the accuracy and relevance of the wording and composition of CTA item 3.1, Teacher B said:

> *"Item 3.1 should have been broken down into sub-questions. It was for 8 marks and they do break it down to some extent. Your top students are fine with it but your slower students need to be asked things much more specifically. Perhaps wording the question differently, like 'what is a wetland?' and, using the description of a wetland, give four reasons, etc... At this level it was too vague, especially for the slower students. The top ones would probably be alright with it but the slow ones missed the point completely".*

It seemed that this teacher believed that the question should have been made more explicit for the weaker learner who could then have had an opportunity to describe a wetland. Although the new curriculum recently acknowledged the need for learners to recall meaningful information when needed, it did not imply that learners should memorise material that has no meaning for them. A more advanced ability to test was 'comprehension', which was presented in this question, where the learner had to explain in his or her own words the reasons for preserving the wetlands. In this way the learners' values were elicited in relation to the environment and sustainability - which was very much emphasised in the recent new curriculum (DoE, 2003b). The problem did not necessarily lie in the phrasing of the question, but it was also possible that the learners did not know how to interpret the picture and translate it into words, or text given. One of the learners stated that: *"It was like an English comprehension test...not straightforward".*

During 2005 many environmental problems were discussed on television and presented as articles in the newspaper, and many learners should have been able to defend an argument for or against a particular situation. The manner in which the question had been asked encouraged the learners to think analytically, instead of answering a straightforward question, which was recommended by the teacher. On the contrary, it seemed that the learners who under-performed in the overall test, as well as those who spoke English as their second language, answered CTA item 3.1 poorly. There was evidence that the weaker learners - and those using English as their second language - had problems interpreting the question (section 4.4.6). This was apparent in some of the transcripts (see section 4.3.6). These results extend Vygotsky's theory (1978) of social constructivism which viewed learning as a social interaction within a certain context, i.e. there is a strong link between society and the individual learner. His learning theory extends to the belief that "all students can learn" which runs counter to the belief that only an elite group of learners can undertake challenging tasks (Shepard, 2000:7). This implies that assessment tasks like these should be designed to accommodate diverse groups of learners well, so as not to disadvantage them in anyway. However, the CTA - which was the form of communication in this instance - was written in English and so many learners who used English as their second language were seemingly disadvantaged. This stands in contradiction to the intended curriculum with regard to the CTA, which states that the "...language used in the questions and in the texts should be simple enough to enable the learners to engage meaningfully in the activities, i.e. ensure understanding" (DoE, 2002b:10). There was evidence of weaker learners who were also discriminated against, since the CTA questions were not straightforward and explicit.

4.4.3 Critique of CTA item 3.2

When interviewed on the appropriateness of the wording and composition of CTA item 3.2, Teacher B said:

> *"I thought that 3.2 overlapped quite a lot with 3.1. Uhm...that there was a bit of ambiguity there, that I find when as I was going through them, I found, well, I have already given some of this in my previous answer".*

The ambiguity in this particular item had also been highlighted by a subsequent interview with a learner (see later Section 4.4.6, page 152).

4.4.4 Critique of CTA Question 4

When interviewed on the wording and composition of CTA item 4.1, Teacher C said:

> *"These combustion equations were quite complex equations to do for a Grade 9 student. That work comes from the Grade 12 chemistry section. They could have used examples that they are more familiar with".*
>
> *"This work should be made more clear in Grade 9 work scheme. This is Grade 11 and 12 chemistry".*

Although the examples given in the CTA were traditionally taught in the Grade 11 or Grade 12 syllabus, it was mainly the skill that was being tested. Recalling prior knowledge, based on the topic of combustion, it was necessary for learners to know what products were formed from the reactants. However, in this instance, an understanding of the particular skill in transforming diagrammatic representations of molecules into formulae was being tested, not necessarily the content of a section of the Grade 12 syllabus. This was consistent with what was written in the Natural Science Policy document (DoE, 2002c:9), viz. "…competence involves process skills such as transforming information from one form to another". It was also consistent with the draft framework for the development of the CTAs (DOE, 2002c:9), viz. " …this is a type of assessment that emphasises the learners' ability to use or transfer their knowledge, understanding and skills and outcomes…".

The teacher's response implies that at least some teachers are not satisfied or have not accepted this type of questioning, which is based on the transference of skills. The teachers' recommendation of familiar problems implies that the level of cognitive competence referred to by the question was too high; and that questions based on 'recall' which were classified under a simple cognitive competence level were recommended instead. Teachers were finding it difficult to accept the new form of assessment. A possible mismatch between the intended curriculum and the perceived curriculum may have been apparent.

As commented earlier (section 4.3.8), the technique of using imagery in the teaching of chemistry is a positive move to making the subject less abstract and facilitating the learning of chemical formulae.

Teacher D said:

> *"Ons het die natuur gedeelte oor gebalanseering van vergelykings en formule baie goed behandel. Dit het ons deur die jaar gedoen, en so die kinders is vertrou daarmee maar 'n skool byvoorbeeld wat dit nooit gedoen het nie, jy kan nie nou binne twee, drie dae vir 'n kind in die GTA (A) dit verdydelik en nou verwag hy moet dit in GTA (B) ken nie".*
>
> We handled the section on balancing equations very well. We did this during the year but a school that did not do this section cannot be expected to know it and write on it in Section B after been taught only two or three days in class.

This teacher seemed to think that some learners may have had insufficient preparation time in which to learn the particular skill of transforming molecular diagrams into formulae. This could possibly be a factor that contributed to some learners' poor performances in these particular items.

4.4.5 Critique of CTA Question 5

When interviewed on the wording and composition of CTA item 5, Teacher A said:

> *"There were three things that I found problematic. The one is having it as a split question where you have to refer to three graphs and continually going backwards and forwards. What tended to happen is the slower kids only looked at graph C because that was on the page that the question was on. The question was quite clear that you had to use all three. The paper should have been designed so that it was on facing pages. The second problem was in graph B. The label on the y-axis says 'total poison', whereas the units of it are actually in concentration, not total amount of poison; and also that it is contradicted as well as with page 12 where it says a factory ' pumps out a large constant', and presumably the constant amount of poison is the total poison. Again, that disadvantaged the clever children who were now very confused as to what was going on. Some of them realised that the units were concentration and therefore ignored the word 'total', but I think it's bad planning in terms of the person setting it. This question was way too abstract for the average student. Generally our average to bottom students wrote close to nothing for it. They were completely overawed by having to take three different graphs, pull all the information together and come up with something. Mostly I would say that the question was exceptionally badly done. It was a good question but it would have been a good question for more like a Grade 11 or Grade 12 thinker rather than an average Grade 9".*

There were obviously many suggested reasons for the learners' poor performance in this particular question (Table 4.5) and the above comment from the teacher summed up several possible factors that may have influenced their achievement. According to this teacher, the question was a very complex one for an average Grade 9 learner to handle. It required the learner to work with three different graphs, but all of the graphs were not supplied on the same test page, so learners had to turn pages repeatedly to be able to explain the influence of low rainfall on the bird population.

These comments were supported by Chandler and Sweller (1991) who also showed that the presentation of poorly arranged data caused learners to divide their attention among the various pieces of data. This created 'cognitive load' which, in turn, led to an inefficient processing of information. Incorrect labelling of Graph B by the CTA test constructor also seemed to have confused some of the higher achieving learners who knew what the units for concentration were. Instead of *"total poison"* the phrase should have read *"concentration of poison."* Ferry, Hedberg and Harper (2002) stated that context played an important part in the interpretation of graphs and tables. They also believed that it was important that key terms in the text were understood and were clear to the learners.

The term 'process skill' was originally intended "to refer to the learners' cognitive activity of creating meaning and structure from new information and experiences" (DoE, 2002c:13). If this were the case, then - according to the analysis recorded in

Table 4.5 - many learners in the current large scale study had not reached this particular stage of cognitive development. This level of cognitive competence, viz. complex cognitive competence - which is the middle level (Green & Naidoo, 2006) required the following skills: interpreting information and communicating the science information. According to the teacher, this question disadvantaged the weaker and average learners, which meant that these questions were not suited for all learners. Consequently, they should have been given appropriate assessment tasks modified to suit their cognitive level, and they should not have been expected to tackle tasks that were beyond the thinking of an average Grade 9 learner. Perhaps the level of wording of this CTA question was more suitable for a Grade 11 or Grade 12 learner.

4.4.6 The interviews with learners: additional results and findings

In general, learners in the focused interview were eager to answer the questions and to highlight certain questions with which they had problems. Although only a few selected quotations will be given below, it was hoped that cognisance would be taken of the learners' comments by teachers, future CTA examiners and curriculum planners to develop new teaching strategies and improved questions in the CTA, and to place more emphasis on a description of model classroom lessons. In this section each interview question will be presented and integrated with its discussion and the relevant quotations of learners.

<u>Interview Question 1</u>

Do you think the questions were set in an unfair or fair way? *Probing questions:* Did you find specific questions difficult? Give me an example. Why?

The majority of learners interviewed said that they found Question 2 (identifying variables) to be difficult, followed by Question 4 (chemistry), Question 1 (electricity). Question 3 (wetlands) and Question 5 (interpreting graphs).

Some of the reasons that learners gave relating to the perceived unfairness of the test were:

> *"Yes it was unfair because this English…it was too difficult for me".*
>
> *(Xhosa learner)*
>
> *"Yes I think it was unfair because… the questions were so hard for me. I didn't understand".* *(Xhosa learner)*

The above quotations were quotations from Xhosa-speaking learners. It seemed that language was a factor that resulted in at least some of the learners' poor performances.

Learners who were interviewed reported that they found the table in Question 2 of the CTA confusing and said that they did not understand the question. Typical responses were:

> *"I did not understand this…it made me confused".* (referring to the table).
> *(English learner)*
>
> *"I don't really understand voltmeters, currents and amps and reading this table was a problem".*
> *(English learner)*

It seemed that many learners were not taught the concept of "voltage", and it appeared likely that too much unnecessary information had been given in the table (Question 2). These responses strongly corroborated what teachers had said after being interviewed.

Referring to CTA Question 3, some learners commented that they were not familiar with the style of questioning, and said that the items were ambiguous - which was also corroborated by a teacher (section 4.4.3, page 149). Three examples of responses were:

> *"I don't think we were exposed much to this type of questions".*
> *(English learner)*
>
> *"Not used to the type of question".* *(English learner)*
>
> *"They were repeating these questions - because every question we had to, like, look at the answer before and then try to work out from there".*
> *(English learner)*
>
> *"Too much to read".* *(English learner)*
>
> *"It was like an English comprehension test…not straightforward".*
> *(English learner)*

These comments supported Bansilal's (2008) findings which also recorded that learners had difficulty with contextualized tasks and that they were disadvantaged. These tasks required more reading and were similar to literacy tasks, as indicated by one of the above learners. This skill of reading and interpretation referred to the complex cognitive competence level which was not based on simple tasks that required the learner merely to recall prior knowledge. The above comments also support Black's (1999) argument that an assessment instrument should be carefully developed to avoid certain learners from being disadvantaged. His argument is an extension of Vygotsky's (1962) theory, cited in Black (1999), that viewed learning as a social interaction and that the nature of the discourse (the CTA) would have an influence on learning, viz. on the learners' performance in this instance.

Referring to Question 4.1 of the CTA, some learners commented that they experienced problems with interpreting the diagrams of molecules given. Typical quotations were:

> *"Hierdie reaksies was moeilik gewees".* (These reactions were difficult).
> *(Afrikaans learner)*
>
> *"I thought they gave it to you in this way so you had to write it in this way.* (Referring to the diagrams). *So I didn't know how to do it in this way".* (Referring to the symbols given). *(English learner)*

The learner thought that she had to represent the answer in the form given by the diagram instead of using a formula as the final answer. It also seemed that some learners did not always read through the questions properly, as one learner admitted

> *"I don't think I read through the question".* *(English learner)*

Some learners said they found difficulty in reading the points on the graphs in CTA item 4.2 and that these kinds of questions were different from what they have been exposed to. One learner said:

> *"The graphs was OK and everything... (pause).. but it was just ...uhm... It looked quite easy but then... uhm...the whole question itself wasn't asked the way we would have wanted to. It was in like a high, difficult way to do it. So it wasn't very easy".*
> *(English learner)*
>
> *"The way the teacher explained it and the way it is in here, it wasn't exactly the same".* *(English learner)*
>
> *"I could not make out what to do...how to use the graphs...I did not understand the question...it was hard".* *(English learner)*

It appeared that these learners were used to been tested on what they had been taught. They found it difficult to answer questions that had been put to them differently, or that they were not used to. Graphical interpretation is a skill classified under a middle complex cognitive competence level (Green & Naidoo, 2006). Once again, learners had a problem in transferring the necessary skills emphasized in the curriculum (DoE, 2002a). In future, if they are given enough examples to practice by using different contexts, then perhaps they may develop the desired skill in interpreting graphs and be able to transfer this very important skill in different contexts. The presentation of the points on the graphs by the CTA test constructor was confusing to some learners, as reflected in these learners' comments:

> *"The way they mark it…like here you're not sure if it's on block or on the line".* *(English learner)*

> *"I found it difficult to read the dots…it was not very clear".*
> *(English learner)*

This reveals that some learners were disadvantaged by the design of the question.

Interview Question 2

Did you find the language used in the test difficult or not? *Probing question:* Why? (Would you have preferred the Natural Science CTA to have been written in Xhosa?)

Although only 52 learners were interviewed, about half of these learners learners recommended that the language used in the CTA could have been made more simple and clear. Several learners also pointed out that the CTA was incorrectly translated from English into Afrikaans. Although many of the learners who spoke English as their second language said that they found the language used in the CTA difficult to comprehend, most of them commented that they preferred to write it in English.

The following quotations from learners seemed to sum up what some of them thought:

> *"Some words…they ask it weird. Instead of just it saying it more simple, they put these big words in there".* *(Xhosa learner)*

> *"The language was too high (meaning difficult)…it took us long to read".*
> *(Xhosa learner)*

> *"Ja, dit was moeilik. Hulle kan dit meer "straightforward"gevra het".*
> *(Afrikaans learner)*
> Yes, it was difficult. They could have asked the questions more straightforwardly.

> *"Die taalgebruik was van die slegste, slegste gehalte want dit was direk van engels vertaal. Hulle het dit woord vir woord vertaal en nie sin vir sin nie".*
> *(Afrikaans learner)*
> The language used was the worst since it was directly translated from English. It was translated word by word instead of sentence by sentence.

This is proof that the language used in the CTA, disadvantaged some learners. Thus, if a CTA needs to be translated, it can be argued that it should be checked thoroughly by a language translation expert before being printed.

Interview Question 3

Referring specifically to CTA Question 2, this question is about using the investigation method. Many teachers complained that this question needed attention.

(i) Do you know what a variable is?
(ii) Explain to me in your own words what a variable is.
(iii) Did you learn about variables in your class?
(iv) When or where?

Approximately three quarters of the interviewed learners could not explain what a variable is. Although many mentioned that they had learnt it in class, they could not explain what it described. This appears to account for the high percentage of learners who performed very poorly in CTA Question 2. It seemed that the learners were exposed to this type of question for the first time only when doing the CTA, as mentioned by two learners after being asked whether they had been taught in class about variables: *"No, only in the CTA"* and *"We didn't learn about these things"*.

'Planning science investigations' had been identified in the Revised National Curriculum Statement (DoE, 2002c:14) as one of the process skills considered essential for creating outcomes-based science tasks. Possibly, however, either it had been poorly taught in 2004 or it had been left out completely in Grade 9. Perhaps some teachers did have the motivation, drive, knowledge and enthusiasm to develop problems that would facilitate learning of variables but, for various reasons, not every teacher would have had these. There was evidence to suggest that teachers should have been given a guidance manual or textbook alongside the policy document with specific examples or references to study for tackling certain difficult concepts.

Interview Question 4

Referring to CTA Question 4.2 and Question 5, could you, or could you not, make sense of the graphs? Probing question: Why?

Approximately three quarters of the learners reported that they had difficulty interpreting Question 4.2. Many of the reasons given were based on the presentation of this item and on the learners' insufficient practice. The majority of learners said they found the bar graphs in Question 5 easier to interpret. Typical responses supporting this conclusion were:

> *"I think we didn't understand it because there's too much things on one page".* *(English learner)*
>
> *"Straight line graphs...you can't read it properly. Bar graphs are easy to read".* *(English learner)*
>
> *"We didn't do a lot of straight line graphs. It was mostly just bar graphs and pie charts".* *(English learner)*
>
> *"I do not know this graphs* (pointing to line graph) *...it is too difficult".* *(Xhosa learner)*

In his study on teachers' process skills, White (2003) stated that the pictorial presentations in the bar- and pie- graphs were quickly and easily interpreted. However, the line graphs were more abstract and therefore might have required a deeper understanding of how the numbers on the axis relate to each other and to the line on the graph in order to answer questions. In the present study, it also appeared that a few learners had difficulty in reading the points from the straight line graph because it had decimal numbers. This was one learner's response:

> *"Omdat hierdie een is met 0.2 of 0.3 gewerk en hierdie is net ronde getalle... by die kolom grafiek".*
> Because this one uses 0.2 or 0.3 (referring to the line graph) and these are just rounded numbers...from the bar graph (referring to the bar). *(Afrikaans learner)*

She also mentioned that rounded numbers were easier to work with, as used in the bar graph, instead of decimals which were used in straight line graphs. Other responses were:

> *"Because it was a line graph, and I'm not quite good in the line graphs, because most of the time we did the bar graphs. So it is a new thing for me in high school".* *(English learner)*
>
> *"Because we weren't exposed to such kind of graphs".* *(English learner)*
>
> *"There were too many graphs...they confused me".* *(English learner)*

Learners cannot be expected to perform certain tasks if they have had insufficient practice with them. These responses from learners corroborated prior research on graphical presentation and the degree of correct interpretation of certain types of graphs, as discussed earlier in Section 4.3.9. When learners interpret graphs (Ferry, Hedberg & Harper, 2002) they often have to re-sort values in their heads and this created cognitive load which inevitably led to errors, and therefore time was required for learners to do this activity. It seemed that learners lacked certain skills associated to graphical interpretation. The learners' responses imply that not enough time was available for them to read through the question properly and that they had not enough practice on straight line graphs. This skill of graphical interpretation refers to the complex cognitive competence level at which learners have to relate two or more concepts (Green & Naidoo, 2006). However, it is difficult to link these factors with any theory. It can only be noted that there was insufficient time for them to complete test and they were not well prepared for the test. This was also revealed in the interviews with the teachers. However, whether or not this time factor is crucial for learning and fair assessment could be questioned.

A quarter of the learners mentioned the time allocated for the CTA test as a mitigating factor, which might explain why many learners did not attempt to answer Question 5. One learner said:

> *"The graph does not usually tell you a lot about what is going on. We have to make out what we see from it. It takes a long time for you to grasp it as well, because you must think of what you see... and everybody sees it from a different perspective. So this stuff takes a lot of time in the exam, and time was very little in the exam, and not everybody finished the paper".*
>
> *(English learner)*
>
> *"I had to read the question and then look at the graphs. We needed more time...not use to so many graphs for one question".* *(English learner)*

Interview Question 5

Referring to item 4.1(a):-

(i) What do you understand about these diagrams? What are they showing you?
(ii) Did the key in item 4.1(a) help you find the formula?
***Probing question:* Was it useful?**

Although many of the learners could not answer items 4.1(b) and 4.1(c) correctly. about three quarter of the interviewed learners were able to describe the diagrams in 4.1(a), and most of the learners said they found the key helpful. This is how two learners described the presentation of the question:

> *"I enjoyed this question. They show pictures of the way atoms are bonded. Yes I suppose it did* (referring to the key as being helpful). *It told us which ones are which and, looking at an atom that is bonded in a certain way with certain other atoms. We can therefore guess the formula, and sometimes it will be a formula that we know and be able to know exactly what the chemical reaction is".*
>
> *(English learner)*

> *"It's like a typical picture story using chemicals. This is perfect. The teacher writes it on the board and you don't actually have that perfect picture. You just see how they calculate it, but with the picture you can actually see... it's more interesting".*
>
> *(English learner)*

It seems that the diagrams were particularly helpful to at least some of the learners in that they made the CTA question less abstract by making it more visual and interesting.

These learners were not always clear when describing the diagrams. One learner seemed to be confused between products and reactants:

> *"Here they give us the key which makes it easier. You combine the products together and then you come out with the reactants".*
> *(English learner)*

One unusual learner incorrectly described atoms as 'antonyms':-

> *"Uhm...that some are antonyms and that some are oxygen and hydrogen. They showing you different things?". (English learner)*

Interview Question 6

Are the types of questions asked in the CTAs different from what you are used to getting in class? *Probing questions*: In what way? Did you get these kinds of questions in your classwork?

About three quarter of the learners reported that the questions in the CTA were different from those with which they were familiar in the classroom. Four main differences mentioned were: the new style of questioning adopted in the CTA (based on real life situations); the novel language format used in the CTA (too long winded); its vagueness (which made it difficult to understand); and the fact that certain questions in the CTA also involved more problem solving skills. Typical responses were:

> *"They are different. When you get a class test it's more specific, but with this CTA it was a bit vague". (English learner)*

> *"In a way they are kind of different. They set out differently, different wording, so it becomes a bit tricky when you get to a question" (English learner)*

> *"Yes, its more advanced I think. It makes you think more and...uhm...I think its good though. We were expecting it to be more difficult". (English learner)*

> *"Yes. In the way the questions were asked...they are different. Like... they asked in more complex ways". (English learner)*

> *"A little bit different but they still understandable. Questions in class are a little bit more straightforward. The CTA was a bit confusing by the way they phrased it". (English learner)*

> *"In class Miss... they will ask you things more ...like straightforward... what you done and CTA, it's like more problem solving". (English learner)*

> *"Its based on a story…but this makes it difficult to understand because too much reading."* *(English learner)*

> *"Yes…when a teacher writes for you in class he/she makes the words for you to be easy and professionals don't think about you…they just write what they understand".* *(Xhosa learner)*

These findings support those of Boaler (2003), who believed that standardized testing discriminated largely against certain learners at low SES schools and against those learners who never spoke the language of the test. These responses of learners can be explained in the light of Vygotsky's (1978) theory of social constructivism, that social influences cannot be separated from the individual learner. Hence, Black's (1999) view of assessment is propelled by this theory – that believes that assessment tasks should be carefully designed to prevent any form of bias. Also, this type of contextualized task raises issues of concern regarding social influences and language, as this study and past studies have revealed (Boaler, 2003; Bansilal, 2008).

There were a few child's who disagreed with the above learners' responses. This is what two other learners said:

> *"No it isn't very different. Just the variables section".* *(English learner)*

> *"A little bit different. In classwork you did not see the drawing* (referring to question 4.1). *You just learn about oxygen and nitrogen".* *(English learner)*

These learners viewed the style and format of the CTA as not totally different, but different with regard to certain questions only.

Some learners commented that the test had questions based on real life situations. A typical response was:

> *"They do try to relate to the real world. They give examples in 4.1… Hans and Sally also set (Question 4.1). Whereas in science we get more a divorced view of things so you'd say methane is a gas… I found it quite irritating because they were interfering".* *(English learner)*

> *"Its based on a story…but this makes it difficult to understand because too much reading".* *(English learner)*

It seemed that this learner preferred to be questioned in a purely scientific manner, without any reference or relevance to a real life situation.

Overall the responses from these learners generally appeared to imply that the CTA had a different, sometimes unfamiliar, style of testing compared to a traditional class test. Perhaps more of these questions should be given to learners during normal classroom lessons so that they can get used to them. However, to benefit the learner, perhaps they should be incorporated regularly during the year, and not be presented as a once-off separate section altogether.

4.4.7 The interviews with teachers : additional results and findings

Five teachers were asked these two open-ended questions:

- **How did you find the CTAs of last year?**
  (referring to the Section A booklet)
- **Do you think they should continue or be discontinued?**

The various responses that emerged from the interviews with teachers could be categorised as: (i) pedagogical problems identified; (ii) problems pertaining to the CTA question paper itself, and (iii) recommendations for future Natural Science CTAs. Each category will be presented with a discussion, including the relevant quotations of teachers.

(i) Pedagogical problems identified

All of the interviewed teachers identified **time** as a factor that hindered their ability to do justice to the CTA. Sufficient **time** on tasks was one of the factors that were associated with higher achievement in learners (Reeves, 2005). It seemed that there was not enough time for CTA consolidation since teachers had to do other administrative work. Despite the recommendations suggested by Siebörger (2004), in 1998, the workload of teachers has not decreased. This was summed up by some teachers:

> *"The timing of the CTA exam was a major problem for us because we were administering the exam, preparing question papers for the other grades as well".*

> *"There was not enough time to go back to students to show them where they have gone wrong. This is a problem of doing it at the end of the year in a rush fashion whereas if we do it earlier then we can do the consolidation".*

It also seemed that the estimated time predicted for learners to have been taught CTA Section A in 2004 was shorter than anticipated. One of the teachers said:

> *"It takes up a lot of time. We've had to cut back on other sections. It takes longer than we were told it would take".*

All of the teachers said they believed **that the CTAs should be continued** but that they should have been given sufficient **time** to teach the CTAs thoroughly. Also emphasised was the need for the curriculum to be more specific in relation to sequencing content so that there is consistency in teaching and achievement levels required among schools. Typical responses were:

> *"I do think there's a place for them. I would like to see them continue simply because it gives something that is common to all schools. But I think the proof reading should be a lot more carefully done and should, maybe, be looked at by specialists so that we don't get things like total amount of poison being written in units of concentration, so I think a little bit of specialist input is needed. There should also be more leeway for the teacher who knows what the kids have been taught to mark them as we know we have taught them. You do need consistency, but if you are going to ask for that sort of consistency in your answers you also have to have the same sort of consistency in your syllabus in terms of detailing exactly what must be taught. You can't have the syllabus open-ended but have your answers very restricted".*

> *" I think they should continue, I like them a lot. The way they are put together is very nice. The only thing is we need to get them in time. You don't do justice to something which took hours to put together".*

> *"Ek dink as hulle dit anders deur voor die tyd ..miskien vir 'n mens leiding te gee oor die teme - as hulle vir ons 'n bietjie meer struktuur gee".* (They could give us an idea of the theme to give us guidance - should give it to us in a more structured manner).

> *"I think the whole idea of a common task for everyone is a good idea but they should be giving it to us at the beginning of the year so that teachers can work with it during course of year. But the concern is that teachers will only work through this and not do anything else. But I think if they give us a syllabus and indicate to us the kind of content we need to be teaching students as well as giving us a sample, a CTA that everybody does, then we can throughout the year be doing that and also see the level and the kind of questions that we can adapt to other sections of the work in a similar fashion. But doing the CTA at the end of the year, I don't think it's a good idea. There was not enough time for consolidation and there was not enough time to go back to students to show them where they have gone wrong. This is the problem of doing it at the end of year in a rush fashion, whereas if we do it earlier then we can do the consolidation;* and *If they can explain difficult words...the meaning of the words* (from English into Xhosa) *at the bottom of the page...it will be usefull".*

Although it can be argued that the CTAs were not necessarily content-based but included contextually-designed skill-based tasks, the responses of some of the teachers have implied that the content was the main focus. This is something to be concerned about, since the teachers did not seem to understand the design and intention of the CTA, which was the "ability to use or transfer their knowledge, understanding and skills into action..." (DoE, 2002b:9). However this implication supports Ogunniyi's (1999) argument which claims that it is difficult to set test items that separate process skills and content.

Translations from English into Afrikaans were regarded as poorly done. A teacher from an Afrikaans speaking school said:

> *"Die taal gebruik was vir my baie swak, ...uhm...dis nie direk genoeg, dis nie die taalgbruik wat die kinders gewoond is in vraestelle nie".*
>
> The children were not used to the Afrikaans used; it was very weakly translated.

The manner in which the CTA questions were **presented** also seemed to pose a problem for learners. Typical responses from teachers were:

> *"All the questions were all quite wordy".*
>
> *"You have to refer to three graphs and you continually going backwards and forwards. What tended to happen is the slower kids only looked at graph C, because that was on the page that the question was on. The paper should have been designed so that it was on facing pages".*
>
> *"Question 2 was poorly done. The internal resistance of batteries is matric work. As far as they've been taught, voltage across a battery must always be constant. It was a very, very poorly put together question".*

Some of the questions were regarded as being **too vague** and not specific enough. Responses that supported this view were:

> *"I felt 3.1* (referring to Question 3.1*) should have been broken down into sub-questions. It was for 8 marks and they do break it down to some extent but again your top students are fine with it but your slower students need to be asked things much more specifically".*

It was also felt that certain abstract **questions** were not well suited for the average and slower Grade 9 learner, as revealed by this teacher:

> *"This question was way too abstract for the average student* (referring to Question 5). *Generally our average to bottom students wrote close to nothing for it".*

Although the first activity given in Section A was not tested in CTA Section B, it was **based on Grade 11 work** in which a certain formula was required to derive the weight. The teacher said:

> *"I see the first activity is Grade 11 work because they want them to calculate the weight using the mass and the gravity".*

From an educational perspective, students cannot be given a problem without having been introduced to the concept. Even those Grade 9 teachers who were not familiar with the Grade 11 work themselves had difficulty understanding the questions, and some needed to consult with senior teachers, as this teacher, who came from a well resourced school, said:

> *"Its not easy, I don't think...It sets a high standard which is good but...we had to do a lot of preparation. We had to go to our science teacher to ask for assistance as well in some of the questions".*

Therefore it is suggested that the CTA examination papers arrive at schools **earlier** in the year, to enable teachers to become aware of the skills and concepts required and necessary for Grade 9 learners before they enter the FET (Further Education and Training) phase.

Studies have shown that prospective teachers are not necessarily familiar with certain process skills and that they need time and support to be able to grasp these themselves before teaching them to learners (Sadeck & Scholtz, 2003; White, 2003).

The above teacher's response and the responses of others have implied the need to be given sufficient time to teach the skills that are necessary for answering Section B. This finding supported a suggestion made by an article in 2002 in which two schools trialled the CTA for the Human and Social Sciences Learning Area of C2005 (Wilmot 2003). The article contained evidence which suggested that creative and systemic curriculum innovation, in this case the performance based tasks, required considerable time and effort which created pressure for busy teachers, even in resource-rich schools with small sizes.

Certain questions were referred to as being **ambiguous**; for example item 2.6:

> *"The word 'matter' is a very ambiguous one. It could rather have been written as - What is the question that they are trying to answer?. But the 'matter' - most kids look at matter as being physical matter rather than an abstract thing so that was a problem for some of them just understanding what they were talking about".*

> *"I thought that 3.2 overlapped quite a lot with 3.1...uhm...that there was a bit of ambiguity".*

Once again, the instrument, presented problems, which had a negative affect on the learners answering correctly.

(ii) Analysis of interview responses pertaining to the CTA question paper itself

I have analyzed the learners' and teachers' combined responses during the interviews in relation to the ten criteria for evaluating the quality of an achievement test specified by Ebel (1972:359-360), together with three additional criteria appearing in the RNCS (2002c:79):-

(a) **Fairness** – Several reasons suggested that the CTA test might have been partly "unfair". These were: the complexity in the language used - especially for the Xhosa-speaking learners; and the incorrect grammatical translation of the CTA into Afrikaans. The use of concepts that were not normally taught in Grade 9 (e.g. *voltage; resistance*) might also have contributed to the unfairness of the test. Also contextualized questions disadvantaged many learners because they were not familiar with the style of questioning; too much reading created a problem for learners who used English as their second language and the weaker learners, which were revealed in the interviews.

(b) **Limited time** was definitely a factor that could be attributed towards the CTA test being "unfair", since teachers said they were not given the opportunity to teach the pre-requisite Section A thoroughly enough, with no time for consolidation. This meant that formative assessment was done inadequately because learners received no feedback with regard to their performance on Section A. With regard to the '**speediness**' of the CTA, the time allocated for completion of the test might have been too short because 8% learners appeared to run out of time.

(c) The CTA lacked **objectivity** to a certain extent since the words used in certain questions in the test were reported by several teachers and learners to be somewhat vague and were not specific enough for the average Grade 9 learner. There was also a trace of ambiguity in the wording of certain items.

(d) During the interviews it became apparent from the responses that certain items in the test **discriminated** between learners of higher and lower achievement and seemed to advantage the above average learner. Also they may have disadvantaged the learners who came from a non-English background.

(e) Some responses obtained during the interviews conducted with particular learners and a teacher made positive reference to the perceived **'relevance'** of the CTA. Relevance is regarded as one of the key aspects of quality in a test. The criterion of "relevance" is not intended to guarantee high-quality items; only to increase the probability that the items included in the test will provide tasks appropriate to the purpose of the test (Ebel, 1972: 364).

It seemed that the criterion of relevance had been met to a certain extent with regard to the Natural Science CTA. Tasks relating to certain questions in Section A of the CTA were issued to learners to do in order to bridge and allow them to attempt particular questions in Section B. However, whether or not it was done thoroughly should be further investigated.

Certain process skills like: 'communicating science information,' 'recalling meaningful information', decision making', 'interpreting information', 'inferring', 'planning science investigations (identifying variables)', 'raising questions about a situation', 'problem solving', 'applying knowledge', and 'justifying an argument' are all skills that were identified as relevant through reaching consensus with experienced teachers and a subject advisor, as mentioned earlier in the previous chapter.

References to "real life situations" emerged during the interviews with learners and teachers. The goal of the criterion of relevance suggested by Ebel (1972:364) was to provide an answer to the question, "Does an item like this belong in a test intended to serve this particular purpose in this particular set of circumstances?" This goal is not concerned with such things as item difficulty, possible ambiguity, grammatical flaws, semantic weaknesses or any other characteristics that might affect the discriminating power of the item but which do not affect its intent. If the intention of the CTA was to create an opportunity for learners to experience a variety of skills, knowledge, attitudes and values (SKAV) as emphasized by the Western Cape Education

Department (DoE, 2002c:3) as requirements for the General Education and Training Certificate (GETC), then it has met these criteria.

(f) Using the CTA test total scores of 1572 learners, the computed Cronbach alpha **reliability** coefficient of the CTA in the main study (Phase II) was found to be $\alpha = 0.91$. This is a very acceptable value.

(g) It seemed that the CTA had a fair degree of **"efficiency"** since provision was made for analytic and partial-credit scoring, not just all-or-none scoring in its use of student's time.

(h) Since the CTA tested mainly process skills and LOs, it can be said that the CTA was fairly **balanced** in that most of the categories mentioned in the RNCS were tested, as will be discussed later (Research sub-question no.4).

(i) According to Ebel (1972), if a test item has a score below 30% then it is regarded as too hard, but if it has a score above 70% then it can be regarded as too easy. Of the 25 items tested, nine had a mean score below 30% but none of the items scored above 70%. For example, the following items could have been too difficult for a Grade 9 learner: item 2.1 had a mean score of 12% and 4.1(b) had a mean score of 25%. The test revealed that a few items seemed to be too difficult for the learners but the majority of items seemed to be satisfactory in terms of **difficulty**. However, the majority of learners interviewed seemed to have found the CTAs different and of a higher standard to that of classroom work (which made it difficult to understand) (see page 158). According to the 'Declaration of the framework for the assessment and promotion of learners in Grade 9…' (Government Gazette No. 25699), the descriptor code for "partially achieved" is 35%-39% and 1-34% for "not achieved" (DoE 2003c:9). In this instance, the mean score for learners' overall performance was 38.3% which meant that the learners had an average rating of "partially achieved".

(j) Although **specificity** was not used practically as a basis for judging the quality of the CTA test, it could be argued that the test did have a certain degree of specificity since it required learners to complete Section A before they could attempt the test in Section B. It would seem unlikely that any novice who did not have any knowledge of the field covered by the test would be able to have attained the acceptable level of achievement.

(k) During the interviews it seemed that the criterion of "**strengthening the capacity for school-based continuous assessment"** stated in RNCS (DoE 2002c:79), was not satisfactorily met due to limited time. Continuous assessment was described as that which covered all the OBE educational assessment. However it seemed that the assurances of **supporting "the growth" of learners**, **supplying "feedback from learning and teaching"** and **providing "feedback from learning and teaching"** (DoE, 2002c:78) did not occur because the teachers were not given sufficient time for proper teaching, learning and formative assessment, which were crucial. Many interviewed teachers revealed that insufficient time had resulted in poor consolidation of work which meant that little or no formative assessment had taken place.

(l) With regard to **ensuring consistency in teacher judgements**, this was reported to be partially achieved. The argument for it being partially achieved was based on the fact that standard assessment criteria were issued to all teachers to use. Contrary to this argument was the "mismatch between policy intention and policy practice" Sayed (2002:29); which was stated by one teacher:

> *"...if you are going to ask for that sort of consistency in your answers you also have to have the same sort of consistency in your syllabus in terms of detailing exactly what must be taught. You can't have the syllabus open-ended but have your answers very restricted".*

(m) One of the purposes of the CTA – **to promote a common standard** – appeared to have been an unlikely achievement judging from the huge performance gap between the lower SES schools and the higher SES schools (Figure 4.20).

(n) Attempted efforts were made in Section A to ensure expanded opportunities for learners by assessing them on different tasks but whether these subsequently materialized has not been investigated during the interviews.

The above criteria, taken from Ebel (1972) and RNCS (DoE, 2002c), was not as specific as the Australian criteria (page 62). For example: the Australian criteria included "degree of ambiguity" and "emphasis on prior knowledge"- which were not clearly evident in Ebel and the RNCS. This needs to be addressed and be brought to the attention of all examiners, especially if prior knowledge has been taken for granted and not emphasized enough. The criteria of any standardized test (in the RNCS) should be clear so that forms of ambiguity, which can be a disadvantage to learners, as mentioned, can be avoided.

4.5 Content of the CTA

Research sub-question No.3c asked:

"To what extent did the CTA cover process skills, Learning Outcomes and Assessment Standards?"

To determine to what extent the attainment of each Learning Outcome had been applied in the construction of the CTA questions, a group of qualified teachers reached consensus after matching each item with a Learning Outcome (see Appendix 2). All three Learning Outcomes were covered by the various items. Of the 25 items, 64% were identified as testing Learning Outcome 1 (Scientific Investigations); 92% tested Learning Outcome 2 (Constructing Scientific Knowledge) and 24% tested Learning Outcome 3 (Science, Society and the Environment). It was evident that each "Learning Outcome" had been tested.

It was found that Learning Outcome 2 had been tested to a greater extent than the other two. A learner's competence in LO2 can be seen in the ability to collect information from various sources, and to organize and analyze the information. Each learner was building a framework of knowledge by using scientific concepts repeatedly in a widening range of situations.

Building this competence involved process skills such as interpreting information by interrogating pictures and diagrams, transforming information from one form to another (e.g. from text to a graph or vice versa), looking for patterns in data, or expressing a relationship between two variables. It appeared from the results and responses obtained from learners and teachers that many learners had difficulty in achieving the Assessment Standard of this particular Learning Outcome. By definition, the Assessment Standards describe the levels at which learners should demonstrate their achievement of the Learning Outcomes and the ways of demonstrating their achievement (DoE, 2003a). The other process skills identified in the CTA were: 'decision making', 'recalling meaningful information'. 'communicating science information', 'observing and comparing', 'planning science investigations' (describing and controlling variables), 'raising questions about a situation', 'problem solving', 'applying knowledge' and 'justifying an argument'. It seems that a wide variety of process skills were tested in the CTA.

The Assessment Standards that were identified according to the Learning Outcomes were the following: 9.1.1 (Plans investigations); 9.1.2 (Conducts investigations and collects data); 9.1.3 (Evaluates data and communicates findings); 9.2.1 (Recalls meaningful information); 9.2.3 (Interprets information); 9.2.4 (Applies knowledge); 9.3.1 (Understands science as a human endeavour) and 9.3.2 (Understands the sustainable use of the earth's resources) (see Appendix 2). The Assessment Standards were numbered for convenient reference. The first digit signified the grade; the second digit signified the "learning outcome" and the third digit signified the individual Assessment Standard. Teachers were asked to use this system for their planning and recording since the WCED had adopted it for purposes of clarity and uniformity (WCED, 2005:14). After reaching collegial consensus in classifying the Assessment Standards as mentioned earlier, I counted the number of times each Assessment Standard had appeared.

Table 4.6 presents the Assessment Standards and the number of times they appeared in the CTA examination paper.

Table 4.6: Assessment Standards and the frequency with which they appeared in the 2004 Grade 9 CTA in Natural Science (Section B)

Assessment Standard (AS)	Number of times the AS appeared in the CTA examination
9.1.1	3
9.1.2	4
9.1.3	7
9.2.1	7
9.2.3	17
9.2.4	7
9.3.1	1
9.3.2	4

"Interpreting information" (9.2.3) was an Assessment Standard that seemed to have occurred the most. It dealt with interpreting information by translating line graphs into text descriptions and vice versa; by extrapolating from patterns in tables and graphs to predict how one variable will change; and by identifying relationships between variables from tables and graphs of data (WCED 2005:18). It seemed that all the Assessment Standards were applied in the CTA except for 9.2.2 (categorising information) which was not identified. The balance of process skills, Learning Outcomes and Assessment Standards in this CTA cannot be criticised since each category has been sufficiently covered.

4.6 CTA performance scores and socio-economic background

(High, medium and low socio-economic status schools and total performance CTA score.)

Research sub-question No.4a asked:

> **"When the 12 sampled schools were grouped into four bands according to SES (three highest SES, three second-highest SES, three third highest SES and three lowest SES), did the levels of the 12 CTA average scores (totalled out of 80) correspond uniquely with each of the four bands?"**

Table 4.7 presents the mean CTA scores for the different type of schools grouped together according to different socio-economic background and school fees.

Table 4.7: Presentation of the CTA achievements of the different types of schools according to their school fees and SES

School	SES	Annual school fee (rands)	Mean score (out of 80) (%)	Number of learners (% of grade level tested)
BLUE	High	R10 000-R15 000	45.49 (56%)	51 (41%)
RED	High	R10 000-R15 000	56.34 (70%)	150 (96%)
PINK	High	R10 000-R15 000	35.24 (44%)	178(93%)
PLUM	Medium	R7 000-R9 000	39.99 (50%)	129 (65%)
GRAPE	Medium	R7 000-R9 000	36.39 (45%)	96(84%)
APPLE	Medium	R7 000-R9 000	41.10 (51%)	230 (82%)
BETA	Normal	R4 000-R6 000	30.31 (41%)	101 (73%)
ALPHA	Normal	R4 000-R6 000	31.58 (40%)	72 (82%)
GAMMA	Normal	R4 000-R6 000	33.64 (43%)	152(67%)
MARS	Low	R0-R1000	9.26 (11%)	100 (80%)
VENUS	Low	R0-R1000	15.76 (20%)	122 (65%)
NEPTUNE	Low	R0-R1000	9.97 (13%)	240 (92%)

The pertinent schools were ranked in status according to their annual school fees. From the above results (Table 4.7), it is interesting to see that the schools from similar socio-economic backgrounds produced more or less similar CTA mean scores. However, the results also showed that school PINK in the highest SES bracket unexpectedly attained a lower CTA mean score than three schools with a lower SES bracket (i.e. 2nd level medium SES). Possibly this could be due to many factors other than the SES of the particular school. After interviewing the relevant Grade 9 class teacher at school PINK, this is what she said: "*Its not easy, I don't think...It sets a high standard which is good but...we had to do a lot of preparation. We had to go to our science teacher to ask for assistance as well in some of the questions*". It became apparent that she had very little knowledge about the content of certain Grade 9 CTA science tasks herself and she required assistance which, she thought, took up a lot of her time. These could be regarded as local classroom level factors which may have influenced the learners' performance, over and above that of the SES of the school. Teachers' proficiency and content knowledge have been identified as factors that have an effect on learners' 'success (Laugksch *et al.*, 2005).

With the exception of one school, due to other factors besides SES, the mean CTA scores of the four different groups of schools, arranged according to their SES bands, decreased from the highest SES schools to the lowest SES schools.

In the light of the learning theory of social constructivism which extends it theory to an assessment that should be fair to all learners irrespective of their social status (Black, 1999), it seems that the Grade 9 Natural Science CTA, has refuted this claim. Although this study has not only focused on the lower achieving schools, enough evidence of past research has shown that schools of low SES are reported to be disadvantaged against these national assessment tasks (Boaler, 2003). Although the CTA, is slightly different in that it provides learners and teachers the opportunity to learn the appropriate skills to be tested in Section B, by providing learners and teachers Section A, it cannot be regarded as an exception in terms of an equal opportunity for all learners to achieve a common standard as expressed in the RNCS (2002c). The social context of the school reveals in this study that the socio-economic status of the various schools, which were grouped together based on school fees (with the exception of one), scored similar results according to the classified group. Hence the overall achievement level of the schools was very much depended on the SES of the school.

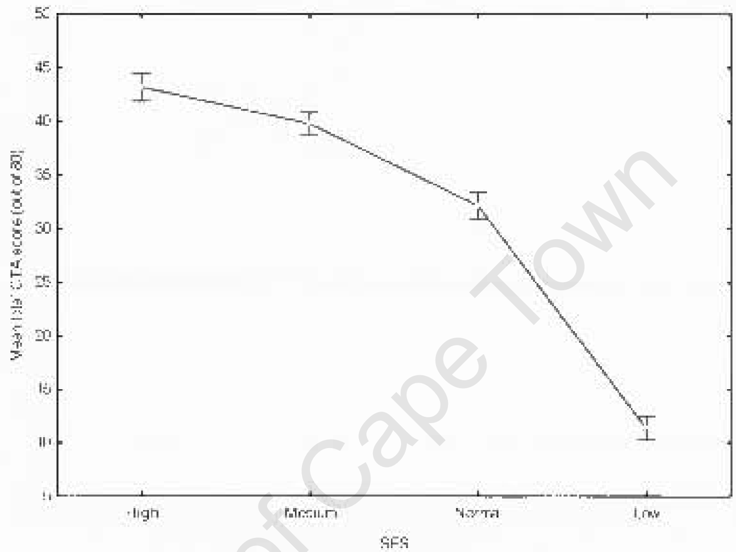
Research sub-question No.4b asked:

"Were there significant differences between the mean total CTA science scores of the four bands of 12 schools grouped according to their SES?"

A graphical presentation of the four total mean scores of these government schools, grouped in threes according to their SES, is shown in Figure 4.20.
Figure 4.20 displays a clear picture of the overall differences in performances of bands of learners from different SES backgrounds. The exceptionally high F-ratio shows that there was a highly significant difference in performance scores between schools with different SES levels. The mean CTA total score of learners from the low SES level (12%) was well below the mean score obtained by the high SES level learners (43%). This was a disturbing output in terms of "promoting a common standard setting", emphasised as one of the purposes of the CTA (DoE, 2002c:79). It seemed that the performance gap was not wide between the high SES level learners

and the medium SES level learners, but it seemed that urgent intervention measures were needed for learners from the low SES level to reach a reasonable standard of attainment.

Figure 4.20: A graphical presentation of the CTA total mean scores of Grade 9 learners grouped according to their school's SES.



F=631.39; p<0.01**

Figure 4.20 displays a clear picture of the overall differences in performances of bands of learners from different SES backgrounds. The exceptionally high F-ratio shows that there was a highly significant difference in performance scores between schools with different SES levels. The mean CTA total score of learners from the low SES level (12%) was well below the mean score obtained by the high SES level learners (43%). This was a disturbing output in terms of "promoting a common standard setting", emphasised as one of the purposes of the CTA (DoE, 2002c:79). It seemed that the performance gap was not wide between the high SES level learners and the medium SES level learners, but it seemed that urgent intervention measures were needed for learners from the low SES level to reach a reasonable standard of attainment.

Other studies on school effectiveness have shown that home background, socio-economic status (SES) or class can have a large effect on learners' academic performance (Laugksch *et al.*, 2005). The current results seem to have corroborated the findings of Riddel and Nyagura (1991) in which high student achievement in

Zimbabwe also correlated with the type of school attended. They also found that variations in student achievement were due to the schools' failure to control the selections of students on the basis of prior academic achievement. The learners' prior achievements were not asked for, but their SES was inferred from the school fees. Unfortunately no private schools wrote the CTAs. Had they done so, the currently reported findings could have been even more interesting!

The findings in the current study also corresponded to those in Rowan (1999), cited in Porter and Smithson (2001:63). They found that, for many schools in their sample, "prior achievement and SES accounted for as much as eighty percent of the variance in mean achievement among classrooms". Although I did not investigate other factors that might contribute to the low achievement in schools, it was interesting to note that Riddel and Nyagura (1991) also found that students' performances in Zimbabwe were higher in one school when there was a greater availability of textbooks and when there was a larger proportion of trained teachers and teachers who had taught at that school for longer periods of time.

Another factor identified in the South African literature as one contributing to the poor achievement in low SES (level 4) schools has been the difficulty in attracting good teachers to far outlying areas (Rademeyer, 2006). These are influences that could be investigated further. I have assumed that the majority of learners attending the local schools in the Western Cape were there mainly because of their parents' financial circumstances and that the learners attending schools in level 4 were from low socio-economic backgrounds.

There appears to be a definite need for concern for those schools ranked the lowest in achievement linked to their low level of SES. These findings correspond with those of Inal (2002) who found that Cape Town science learners attending schools from a lower SES achieved significantly below all the other schools of higher SES. The fact that the learners did not have English as their home language could also be a factor that contributed to the poor performance of some learners in the 2004 Natural Science CTA.

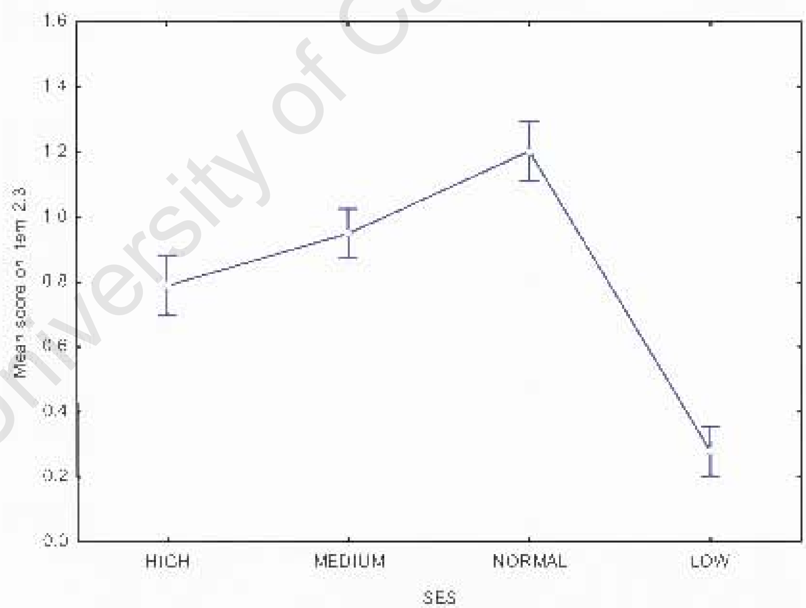
Although there was a distinct pattern in the performances of the total mean CTA scores of learners which decreased from the highest level SES schools to the lowest level SES schools, there were a few exceptions to this pattern with regard to certain individual test items.

Research sub-question No.4c asked:

"Did the high level SES schools perform better than the lower level SES schools on all 25 items in section B of the 2004 CTA examination in Natural Science?"

The answer to this question is "No". Performances by all SES bands of learners were comparable to each other on eight of the individual CTA test items.

Figure 4.21: A graphical presentation of the lower level SES schools (N-level) outperforming the higher level SES schools (H-level, M-level) on item 2.3



F=89.89; p<0.01**

Figure 4.21 is an example of a different kind of pattern of CTA performance means compared to the pattern depicted in Figure 4.20. The declining graphical pattern presented in Figure 4.20 - where the graph decreased from the highest SES to the lowest SES - was not necessarily common. It was not found for items 1.1, 1.4, 2.3, 2.4, 2.7, 2.8, 3.2 and 4.2(a) but it did occur for items 1.2, 1.3, 2.2, 2.5, 2.6, 2.9, 3.1, 3.3, 3.4, 4.1(a), 4.1(b), 4.1(c), 4.2(b)1, 4.2(b)2, 4.2(b)3 and 5 (see Appendix 7), with statistically significant p-values of less than 0.01. The p-value for item 2.1 was not significant.

It was concluded that SES level was a predictor of academic performance score on sixteen out of the 25 individual CTA items. It was interesting to note the nature of the items in terms of cognitive competence levels and whether there were any outstanding differences. The items that displayed a declining graph from high to low SES included only 6.4% of lower level simple cognitive competences, 44.4% middle level complex cognitive competences and 7.9% of higher level advanced cognitive competences (see Table 4.8). The other items that did not comply with the trend in the above graph, i.e. declining SES, included 7.9% of lower level simple cognitive competences, 27,0% of middle level complex cognitive competences and 6.4% of higher level advanced cognitive competences. Although the differences between the lower level simple cognitive competences and the higher level advanced cognitive competences between the different groups of the above items were very small, i.e. difference of 1.6% each, the differences between the middle level complex cognitive competences of the different groups of items were large, i.e. 17.5% in favour of the group of items that presented a graph which showed a decline in the SES of schools. This means that findings for the majority of items (17 items) showed that learners from lower SES schools generally struggled with their performances on most of the items in the CTA which involved skills classified mainly under middle complex cognitive competences. These were: communicating science information, decision making, interpreting information, planning science investigations which included identifying variables, evaluating data and the application of knowledge. It was not the aim of the present study to find the reasons why low SES underperformed in these skills and level of competences. However, past studies have also found that learners from low SES schools under-performed on contextualized tasks (Cooper & Dunne, 1998).

Table 4.8 Levels of competences identified in Section B of the 2004 Natural Science CTA

	Decrease in graph from highest SES to lowest SES	No pattern of a decline in SES
Lower level simple cognitive competences	6.4%	7.9%
Middle level complex cognitive competences	**44.4%**	**27,0%**
Higher level advanced cognitive competences.	8,0%	6.4%

4.7 CTA performance scores with regard to gender

Research sub-question No.5a asked:

"Was there a significant difference between the total achievement score totals of the 912 females and the 660 males on the 2004 Grade 9 Natural Science CTA?"

Table 4.9 presents the mean scores of the learners according to gender.

Table 4.9: Learners' total performance on the CTA according to gender

Gender	Mean score out of 80 (%)	Number of learners
Female	33.1 (41.4%)	912
Male	27.0 (33.8%)	660

$F = 47.7$; $p < 0.01$**

There was an astonishingly highly significant difference of 7.6% between the performances of males and females, with a very high F-ratio of 47.7, indicating that the females seemed to be far better at expressing themselves correctly, since the CTA questions were generally not very direct in nature and required learners to express themselves more. These explanations are supported by past studies by Perry and Fleisch (2006) who believed that girls had better communication skills than boys. These findings were somewhat contrary to the findings of Inal (2002) in his study of ten brief core practical task items which encouraged and measured various manipulative science process skills laid out in the Revised National Curriculum Statement (DoE, 2002c:20). He found that there were no significant difference between the total achievement scores of the males and females on his practical performance tasks. Could the difference in findings be attributed to the fact that a large part of the Natural Science CTA 2004 required learners to interpret contextualized texts that required a lot of reading to express them more clearly? This would have required more higher order skills like problem solving, drawing conclusions and decision making after reading a text, compared to the more technical. manipulative practical approach of Inal (2002) – which encouraged the practice of simpler and less sophisticated skills. This does not necessarily mean that the females were performing better than the males in higher competence level skills, but it seems that females were better at comprehending and translating text. For example, in CTA Question 5 learners had to explain the link between the influence of the low rainfall on the bird population, as well as its influence on the whole ecosystem, which involved interpreting information and communicating science information which are middle level cognitive competences. The different context in which the CTA was set presented questions which expected learners to be able to read the text, interpret the text and respond to questions that required a fair amount of comprehension skills. These types of questions created the gender bias, since it is believed that females have better communication skills (Elwood & Comber, 1996; Howie, 2001; Perry & Fleisch, 2006).

Research sub-question No.5b asked:

> **"Were there significant differences between the achievement scores of the 912 females and the 660 males on each one of the 25 items of the Grade 9 Natural Science 2004 CTA?"**

Table 4.10 presents the mean scores on individual items of Grade 9 learners grouped according to gender.

Table 4.10: Comparisons of the achievement scores of males and females on individual items (n=912)

Item no.	Female (n=912) Mean (%)	Male (n=660) Mean (%)	F - ratio	p – value
1.1	1.91	1.80	2.50	0.11 N.S.
1.2	1.24	1.13	4.24	0.04*
1.3	1.24	1.13	6.79	0.009**
1.4	2.87	2.39	39.17	0.000**
2.1	0.12	0.12	0.01	0.92
2.2	0.31	0.23	12.33	0.001**
2.3	0.78	0.76	0.34	0.56 N.S.
2.4	0.54	0.52	1.08	0.30 N.S.
2.5	0.16	0.10	9.57	0.002**
2.6	0.43	0.25	25.56	0.000**
2.7	0.97	0.83	6.41	0.012*
2.8	1.21	0.93	20.97	0.000**
2.9	1.21	0.87	56.36	0.000**
3.1	3.75	2.92	39.17	0.000**
3.2	1.84	1.73	2.98	0.084 N.S.
3.3	1.60	1.26	35.79	0.000**
3.4	2.83	2.36	32.16	0.000**
4.1(a)	2.12	1.79	21.63	0.000**
4.1(b)	1.14	0.82	15.03	0.000**
4.1(c)	0.43	0.33	8.36	0.04*
4.2 (a)	1.68	1.45	9.11	0.003**
4.2 (b)1	1.16	1.00	13.20	0.000**
4.2 (b)2	1.06	0.86	19.56	0.000**
4.2 (b)3	0.46	0.37	12.51	0.000**
5	2.05	1.29	80.34	0.000**

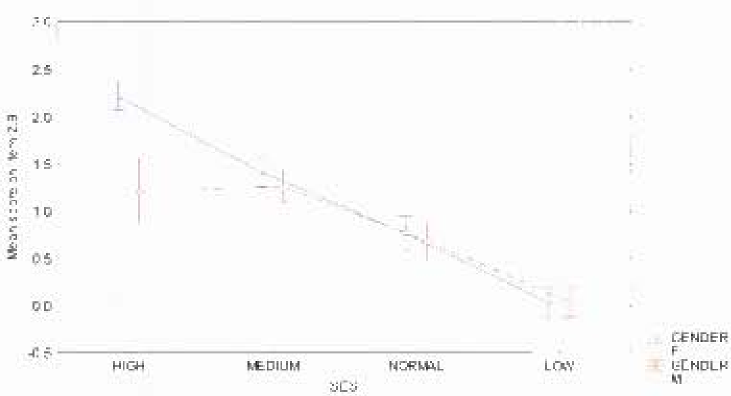
* $p<0.05$ ** $p<0.01$ N.S. = no significant difference

The results in Table 4.9 indicate that there were many highly significant differences in achievement between males and females. The females attained a significantly better mean score than the males on 20 of the 25 items. However, when an analysis of the difference in achievement scores between males and females was done according to the SES of the school, significant gender differences in favour of the boys appeared among only the highest level of SES schools (H-level), except for item 2.6 which showed a significant difference between males and females in the N – level schools (second-lowest SES). It seemed that the males and females from the lower SES schools scored comparably in each individual item. The males scored higher in the highest SES level on items 1.1, 2.1, 2.4, 2.7, 3.2, 4.1(e) and 4.2(a). The females scored higher in the H – level on items 1.3, 2.9, and 3.4. See Figure 4.22.

It is interesting to note that the high SES females scored better on process skills like "decision making", "drawing conclusions" and "justifying an argument" whereas high SES males scored better in constructing a circuit diagram, identifying variables, applying knowledge (balancing chemical equations) and translating a graph into a table. These findings (of the high SES) - on gender differences in performance on particular questions - are very interesting since factors that could have influenced their performances, like class size appeared to have had no influence on the performance differences and thus the argument that females are better in expressing themselves in writing is very strong in this study. Earlier research also revealed that boys tended to outperform girls in the physics section of science which included identifying variables and interpreting a circuit diagram (Bennett, 2003; Levinson, 1994).

Vygotsky's (1972) theory which emphasizes the link between social influences and the development of a learner has been elaborated to learning as a social interaction and extended to the argument of Black (1999), who believes that any assessment task has to be fair for all learners, short of bias

Figure 4.22: A graphical presentation of male (n=660) and female (n= 912) scores for item 2.9, grouped according to four levels of SES



$F=7.35; p < 0.01^{**}$

From the graph depicted in Figure 4.22, it seems that the females from the H-level schools (highest SES) performed better than the males on item 2.9. Learners were required to draw conclusions by studying the CTA graph drawn and the given table. The skills involved were 'interpreting information' and 'communicating science information'. There was no significant gender difference in the performance on item 2.9 learners from the other SES schools, i.e M-level, N-level and P-level SES schools. More examples are given in Appendix 6.

4.8 CTA performance scores with regard to home language grouping

Research sub-question No.6a asked:

"Were there significant differences among the total achievement scores of the Grade 9 Natural Science CTA between Xhosa -, Afrikaans - and English-speaking learners?"

Table 4.11 presents the total mean scores of Grade 9 learners on the Natural Science CTA when re- grouped according to home language.

Table 4.11: Learners' total performance scores on the CTA when grouped according to home language

Language	Mean score out of 80 (%)	Number of learners
English	36.1 (45.1%)	1015
Xhosa	13.6 (17%)	239
Afrikaans	25.7 (32.1%)	318

$F=224.8$ $p < 0.01$**

Statistically there was a highly significant difference between the achievement scores of learners when grouped according to their home language. Table 4.10 records that the test discriminated against both Afrikaans and Xhosa learners. According to the descriptor codes (DoE, 2003a), only the English learners achieved and the Xhosa and Afrikaans did not achieve. Earlier in this chapter the poor level of English proficiency among the English second language participants was noted in their written responses to questions and in their basic grammatical and language errors. These findings correspond with those of Sadeck (1999) where learners also experienced difficulty in explaining their ideas. Table 4.10 discloses that the Afrikaans-speaking learners under-performed by 13.0%, and the Xhosa-speakers by 28.1% relative to the English-speakers on the CTA. These findings are evidence that the design of the CTA assessment tasks, which required reading, could be compared to literacy tasks - as argued by Bansilal (2008) - because the manner in which they were presented was highly contextualized. This may have disadvantaged many English second language participants. These are some of the English first language learners' remarks that substantiate the findings:

> *"They do try to relate to the real world. They give examples in 4.1... Hans and Sally also set (Question 4.1). Whereas in science we get more a divorced view of things so you'd say methane is a gas... I found it quite irritating because they were interfering'* and *'Its based on a story...but this makes it difficult to understand because too much reading".*

If these English first language learners found the text difficult, how would the other learners have coped? Also, the direct and incorrect translation from English to Afrikaans confused Afrikaans speaking learners. Some criticisms against the translations were given in the above interviews by a teacher and learner.

Research sub-question No.6b asked:

> **"Were there significant differences in academic achievement among Xhosa - , Afrikaans - and English – speaking learners on each one of the 25 individual items of the Grade 9 Natural Science 2004?"**

Table 4.12 presents the mean performance scores of the Grade 9 learners on individual items, grouped according to home language.

The findings presented in Table 4.12 indicate that there were highly significant group differences between Xhosa, Afrikaans and English learners on the mean scores for 23 of the 24 items.

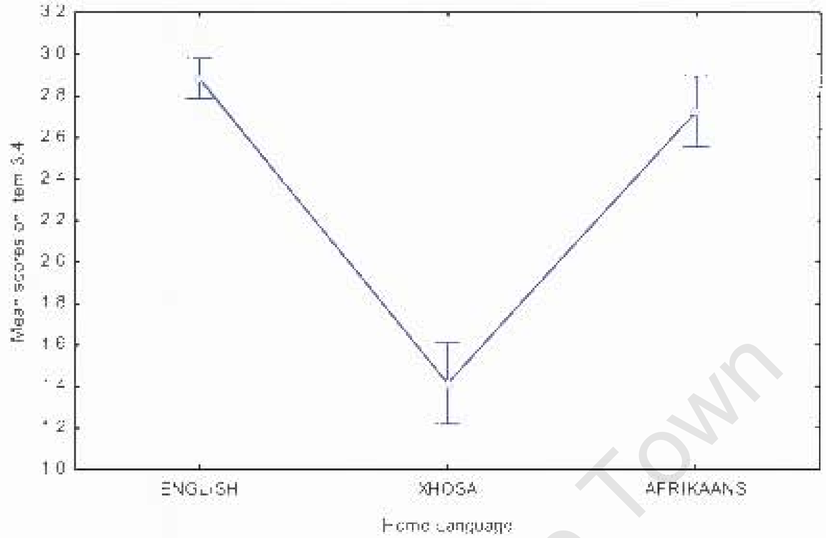
Table 4.12: Comparisons of the achievement scores of Grade 9 learners on individual items, with performances grouped according to language

Item no.	English group Mean (%)	Afrikaans group Mean (%)	Xhosa group Mean (%)	F-value	p-value
1.1	2.16	1.60	0.98	89.70	0.000**
1.2	1.34	1.15	0.65	41.06	0.000**
1.3	1.34	0.99	0.83	49.77	0.000**
1.4	3.06	2.38	1.36	150.54	0.000**
2.1	0.11	0.16	0.13	2.67	0.07
2.2	0.34	0.17	0.13	33.62	0.000**
2.3	0.83	0.93	0.34	35.46	0.000**
2.4	0.62	0.45	0.26	58.90	0.000**
2.5	0.15	0.12	0.07	5.80	0.003**
2.6	0.40	0.35	0.15	12.61	0.000**
2.7	1.14	0.71	0.20	88.63	0.000**
2.8	1.32	1.02	0.22	89.40	0.000**
2.9	1.30	0.59	0.15	83.20	0.000**
3.1	4.03	2.93	1.32	127.12	0.000**
3.2	2.07	1.40	1.13	73.42	0.000**
3.3	1.80	0.86	0.82	159.46	0.000**
3.4	2.89	2.73	1.41	89.24	0.000**
4.1(a)	2.20	1.91	1.12	64.00	0.000**
4.1(b)	1.24	0.90	0.16	48.47	0.000**
4.1(c)	0.49	0.26	0.11	34.95	0.000**
4.2 (a)	1.92	1.32	0.49	107.76	0.000**
4.2 (b)1	1.30	0.83	0.57	94.37	0.000**
4.2 (b)2	1.24	0.63	0.35	147.85	0.000**
4.2 (b)3	0.53	0.25	0.16	86.42	0.000**
5	2.22	1.13	0.49	148.00	0.000**

**p<0.01

A few noteworthy graphical presentations are presented below for selected items by way of illustration.

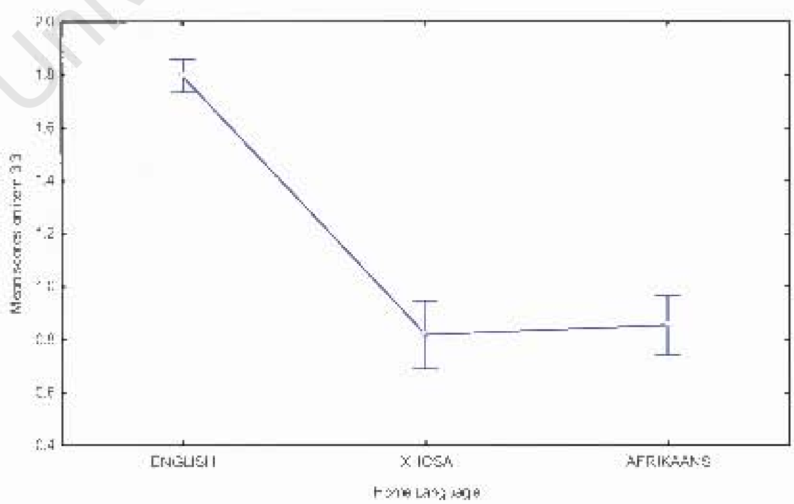
Figure 4.23: Mean performance levels of Grade 9 learners on CTA item 3.4 (Wetlands) when grouped according to home language



F=148.0; p < 0.01**

Figure 4.23 presents the mean scores of learners for item 3.4 (Wetlands), when the Afrikaans learners performed almost the same as the English and learners. It also shows that the Xhosa learners under-performed appreciably compared to the English- and Afrikaans-speaking learners.

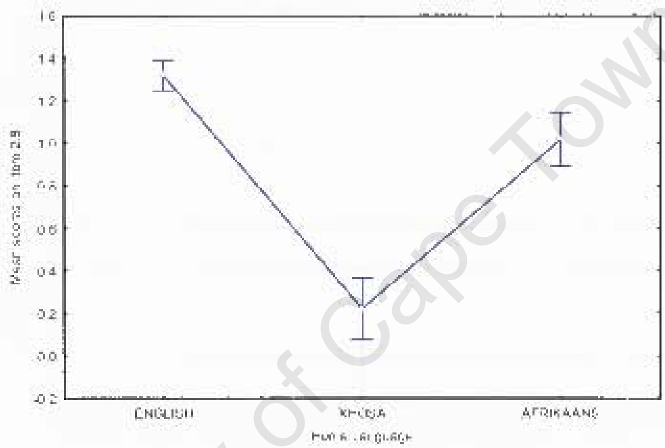
Figure 4.24: Mean performance levels of Grade 9 learners on CTA item 3.3 (Wetlands) when grouped according to home language



F=159.5; p < 0.01**

Figure 4.24 shows that both Afrikaans and Xhosa learners performed poorly on item 3.3 (Wetlands). In this item, learners had to decide on three steps that should be taken to solve the identified problem. Again, learners had to express themselves clearly and it seems that many learners who spoke English as their first language performed better than learners who were Afrikaans- and Xhosa-speaking. Although the CTA was translated into Afrikaans, the Afrikaans-speaking learners under-performed like the Xhosa learners. Could it be because the CTA was not correctly translated, or are there other reasons? This could be investigated further if need be.

Figure 4.25: Mean performance levels of Grade 9 learners on CTA item 2.8 (electricity) when grouped according to home language



F=89.4; p=0.01**

Figure 4.25 shows that most of the Xhosa learners could not draw the straight line graph required for the electricity question.

Research sub-question No.6c asked:

> **"Were there significant differences among Xhosa- , Afrikaans- and English-speaking learners on the total mean CTA score when sub-grouped according to their SES?"**

I was particularly interested to see what effect, if any, the SES of the school might have on the performance of English second language participants.

Table 4.13 presents the total mean scores on the CTA of the Grade 9 learners when grouped according to both language and SES.

Table 4.13: Comparisons of the total achievement scores on the CTA of Grade 9 learners when grouped according to language and SES

Home language	SES	n	Mean CTA score (out of 80)
English	H	314	45.56
	M	445	39.94
	N	101	30.31
	L	155	13.51
Afrikaans	N	224	32.98
	L	92	7.76
Xhosa	H	14	35.21
	M	10	32.40
	L	215	11.32

$F=6.08$; $p < 0.01$**

As might be expected, English second language participants at higher SES schools achieved significantly higher scores than those English second language participants who attend lower SES schools. These findings corroborate the findings of Inal (2002), where English second language participants at high schools situated in privileged areas achieved significantly higher scores than those who attended schools situated in underprivileged areas (townships). The English second language participants from the highest SES schools (mean score = 35.21) achieved slightly higher scores compared to the English first language participants from lower SES schools - N level (i.e. mean score = 30.31), but they achieved a significantly higher score compared to English first language participants from the lowest SES school – L level (mean score = 13.51). It seems that English second language participants from high socio-economic status schools also attained better mean scores than English first language participants from a lower SES (N and P levels). Of particular interest was the finding that the weakest under-performers were the learners in the Afrikaans low SES grouping, so they were the ones who would require the most remedial attention.

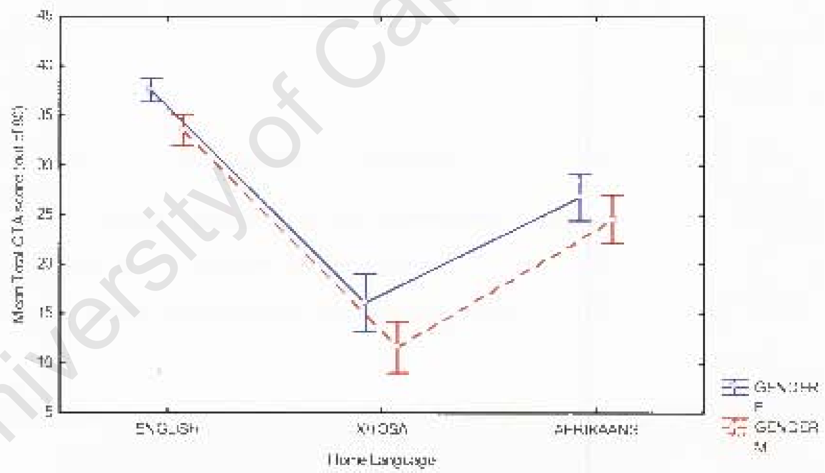
These results are particularly interesting since they appear to show a distinct relationship between home language and the SES level of the school in this particular study. However, these results should be interpreted cautiously, since the number of English second language participants was not very many and only one other study, in South Africa, was found that supported these results. Nevertheless, they support certain aspects or considerations of the theory of social constructivism by Vygotsky (1978) and Black's (1999) view of assessment in terms of the theory – i.e. learning is a social interaction, and that learners are affected by social influences and context in which learning occurs. This suggests that the learning environment had a positive affect on learners irrespective of whether or not English was their second language.

Research sub-question No.7a asked:

> **"Were there significant differences between males and females on the total achievement scores of the Grade 9 Natural Science CTA 2004 when sub-grouped according to language?"**

The statistical analysis showed that there were no significant differences on the total achievement scores between males and females when sub-grouped according to language, as shown in Figure 4.26.

Figure 4.26: Learners' mean total performance scores on the CTA out of 80 when sub-grouped according to language and gender



F=0.53, p=0.59

Research sub-question No.7b asked:

> **"Were there significant differences between males and females on each one of the 25 individual items of the Grade 9 Natural Science CTA 2004 when sub-grouped according to language?"**

The statistical analyses indicated that there were no significant differences between the males and females when sub-grouped according to their home language. Although item 2.9 (electricity) did show a significant difference of p=0.006, this result might be regarded as spurious since one item out of 25 can be expected to be significant purely due to chance at the p=0.05 level of significance, as a general statistical principle.

4.9 Summary of discussions: concluding overview

From the analysis of 1572 learners' results it was found that the majority of learners failed to attain the pre-specified acceptable levels. Of the 25 science CTA items tested, acceptable levels of achievement were attained on only nine items. The most prominent items in which learners seemed not to have performed well were based on the process skills: 'identifying variables' and 'interpreting graphs'.

After studying the scripts of learners, it became apparent that the possible aspects that may have impacted on the low performances of learners were misconceptions, misinterpretations, lack of prior knowledge, language and comprehension skills and graphing skills. Many of the identified misconceptions seem to have originated from a lack of conceptual understanding of the symbolic representations of circuit diagrams. Some learners believed that drawing pictures of the apparatus used in an experiment (the ammeter, battery, wires etc.) could be represented as a circuit diagram – not realizing that each electrical part had a symbol representing it. A common misconception was representing one cell as a battery instead of two. These identified possible misconceptions have been reported in other research literature both nationally and internationally.

Another misconception that emerged was that the belief by some learners that the formula of a substance can be changed. For example, many learners falsely believed the water molecule H_2O, could be written as H_4O_6. According to the "law of definite proportions" this is not allowed, since each substance has its own standard formula that cannot be changed, as has been discussed earlier in the chapter (Question 4). Although the skill of interpreting diagrams and converting them into formulae were tested in the CTA, but not the content and principles of chemistry, this misconception is worth taking note of for the teaching and learning of chemical formulae.

It was difficult to regard certain incorrect answers as misconceptions since some of the answers seemed to occur as a result of misinterpretation and some answers were the result of poor "prior knowledge". In particular, the learners who spoke English as their second language seemed to have had problems, since the questions were not straightforward and required a certain amount of interpretation, and the learners needed to express themselves clearly.

The most prominent requirement that seemed to have had an impact on learners' inadequate performances was the skill of interpreting diagrams, text, tables and graphs. It seems that most learners had difficulty in interpreting and translating the line graphs into text but found the bar graphs easier to interpret. Reading off decimal numbers from the graph and converting the data into table form also appeared to be problematic for learners. Incorrect labelling and choice of graphical representation also seemed to have been common in the learners' responses. Closely related to this was the higher integrated skill of "identifying variables", which many learners appeared not to have accomplished. This was reported in other studies as well. Converting diagrams, and representing atoms into formulae were also performed inadequately by most learners.

The lack of "prior knowledge", which has been identified as an Assessment Standard in LO2, can also be seen as an aspect that contributed to the learners' under-performance. This could be the result of "poor formative assessment" since learners should have been familiar with certain concepts like 'identifying variables' and 'balancing chemical formula', given the fact that they were supposed to have been taught in Section A, which did not necessarily occur in some classes because of limited time. The under-performances of learners could most likely be attributed to the "poor assessment" strategies used by teachers. These may need to be investigated further, since this cause for concern has not been analysed in this particular study.

After the learners and teachers were interviewed, shortcomings were identified with regard to the wording and composition of each item; clarity; length; layout; degree of abstraction; ambiguity; appropriateness for RCNS and diagrammatic representation. Firstly, there was too little time for section A to have been taught thoroughly. Certain concepts like "voltage" and "current" seemed to be unfamiliar to some learners. The skill in translating the visual representation of formulae into symbols was reported to be very helpful but was criticised as Grade 12 work and not suitable for Grade 9. Although, it could be argued that the skill was being tested, and not the content, it was difficult for teachers to separate the two. It also appeared that there was not enough time for some learners to complete the CTA, since some of the questions required a lot of thinking and learners were not very familiar with the type of questioning.

Ambiguity was identified as an aspect of certain questions in the CTA which could have possibly resulted in some confusion for the learners. It was also stated that the language used was difficult for learners who spoke English as a second language. In some respects the manner in which the CTA was translated from English into Afrikaans was seriously defective. Most of the interviewed learners who spoke English as their second language said they preferred to have the CTA written in English instead of in their mother tongue, despite the fact that they experienced problems in interpretation. Furthermore, many of the interviewed learners felt that the questions given in the CTA were very different from what they had been exposed to in class work in terms of the language format, its vagueness and the fact that more problem solving skills were required in the CTA.

The science teachers said they felt that, in principle, the CTA as an educational idea should continue but that it should be given earlier in the year, and that preliminary proof-reading of items should be done by specialists to avoid certain errors. It was also revealed that there should be consistency in the syllabus if consistency was required in the learners' answers. This meant that teachers would need to be given more specific guidelines as to what is expected from them in future in terms of teaching and learning. It also appeared from the interviews that the test discriminated against the below average learner and against learners with non-English backgrounds.

The CTA covered all three Learning Outcomes, Assessment Standards and certain process skills. It appeared that LO2 has been tested to a greater extent than LO1 and LO3. LO2 (constructing scientific knowledge) states that the learner will know and be able to interpret and apply scientific, technological and environmental knowledge if the learner is able to categorise information, recall information and interpret information (WCED, 2005; DoE, 2002a). The latter two process skills were prevalent in the test. The main process skills tested were: decision making, recalling meaningful information, communicating science information, observing and comparing, planning science investigations (describing and controlling variables), raising questions about a situation, problem solving, applying knowledge and justifying an argument and interpreting information.

When the schools were ranked according to the annual school fees, it appeared from the results that schools from similar socio-economic backgrounds produced more or less similar CTA mean scores in science. However, it was also found that one school in the highest SES level attained a lower CTA mean score than three other schools with a lower level SES. This could possibly have been due to factors other than the SES of the particular school. In this study, other suspected factors were not directly investigated.

There were significant differences among the mean scores between the schools from different levels of SES, and it was found that the performance gap between the highest and lowest level SES schools were very big. There was a distinct pattern in achievement levels from the highest SES to the lowest SES in the order: highest SES > medium SES > normal SES > lowest SES. This pattern was evident for 16 of the 25 items on the CTA. The link between the level of cognitive competence and different SES schools seemed quite evident.

There was a highly significant difference between the performances of males and females in the total score of the Science CTA, where females performed better than males. This seemed to indicate that females were possibly better in expressing themselves than males since the CTA questions were not very straightforward in nature, and they required learners to express themselves more comprehensively. For most of the items tested, females outsmarted the males.

There were highly significant performance differences between males and females in 20 out of 25 CTA items in which the females attained the better mean scores. Highly significant differences between males and females appeared among only the highest level of SES schools. It appeared that the females scored better on science process skills like 'decision making', 'drawing conclusions' and 'justifying an argument' whereas males scored better in 'constructing and interpreting diagrams', 'identifying variables', 'applying knowledge' (balancing equations) and 'translating a graph into a table'.

The results also indicated that home language was a clear factor that seemed to bear on the learners' performances in the Science CTA. The test appeared to have discriminated against Xhosa learners and this was especially evident in their written responses to questions and basic grammatical language errors. There were also highly significant differences between Xhosa, Afrikaans and English learners on the mean scores of 24 of the 25 items. In the majority of items, English learners performed better than Xhosa and Afrikaans learners.

English second language participants at higher level SES schools achieved significantly higher scores than those English second language participants who attended lower level SES schools. It also appeared that the English second language participants from the highest SES schools achieved slightly higher scores compared to the English first language participants from lower SES schools but achieved a significantly higher score compared to English first language participants from the lowest SES schools.

Finally, there were no significant differences between males and females on the total achievement scores and on each individual CTA item when they were sub-grouped according to their home language.

4.10 Final Analysis of results

With Vygotsky's (1978) theory of social constructivism in mind, any form of assessment and learning is strongly related to the social context that it takes place in and the discourse within the learning environment. Therefore there is a strong link between the assessment used and the outcomes. With this in mind, it has been argued that assessment should be carefully implemented to avoid any form of bias pertaining to gender, social, ethnic and linguistic groups (Black, 1999).

From the analysis of the teachers' and learners' responses, it is apparent that the implementation of the CTA had many shortcomings which were propelled by social influences and by instrumental design. The link between social constructivism and assessment, as described by Black (1998) and Shepard (2000), supports this view. Social constructivism perceives learning closely related to social influences. This means that the "learners' response will be sensitive to the language and social context of any communication" (Black, 1999: 123). In this case the CTA can be viewed as the source of communication. In the light of this theory, it was necessary for this study to borrow from Green and Naidoos's (2006) framework and the four aspects of the curriculum as defined by Mills and Treagust (2002), cited in Bansilal (2008), to provide a full analysis.

Since scripts from Afrikaans, English and Xhosa learners were analyzed, language and the design of the instrument (CTA, Section B) has been a cause for concern. Some learners who used English as a second language said they found the CTA difficult to understand. The context framed around the CTA demanded good reading, interpretation and comprehension skills which appeared to disadvantage second language learners. The CTA framework document states that "this section [section B] should assess recall and understanding (comprehension and understanding)…" (DoE, 2002b).

The English learners outperformed the Afrikaans and Xhosa learners. The interviews with teachers and learners seemed to suggest that both the language and style of the CTA were common problems among most learners. This may be explained as a result of a poorly translated Afrikaans CTA and the difficulty Xhosa learners experienced in understanding the contextualized questions.

According to Mills and Treagust (2002), cited in Bansilal (2008) the four aspects of the curriculum are defined as: the intended curriculum (the intention of the educational system), the implemented curriculum (instructional practice), the perceived curriculum (learning experiences by the learners) and the achieved curriculum (the outcomes of learners). In this study I adapted one of these aspects according to my objectives. For the perceived curriculum I looked at the experiences by the learners and teachers on the CTA test (Section B). It seems that the good intention of the Department of Education has not been fully achieved. The CTA, which is part of the intended curriculum, is designed to focus on skills as emphasized in a departmental document: 'ability to use or transfer, their knowledge, understanding and skills into action…' (DoE, 2002b:9). However, the responses from the teachers revealed that content and skills were difficult to separate and they preferred questions more suited for Grade 9 learners instead of Grade 11 or Grade 12 learners. Some of their responses were: "*That work comes from the Grade 12 chemistry section. They could have used examples that they are more familiar with*". and "*This work should be made more clear in Grade 9 work scheme. This is Grade 11 and 12 chemistry*". The CTA framework stipulates that "section A creates the content and context for section B" and section B "should reflect a transfer of skills from section A" (DoE, 2002b:10) However, on page 9, it states that "the content and skills… should be age and grade specific" (DoE, 2002b:9). According to the teachers, the content was not for a Grade 9 learner. Although the intended curriculum of the CTA displays noble intentions, it seems that there is a mismatch between the intended curriculum on the one hand and the perceived and implemented curriculum (the CTA) on the other hand. The implementation of the future CTAs should comply by what is stipulated in the policy documents, otherwise teachers are left confused, anxious and end up having no faith in the new curriculum.

This CTA framework document does stipulate that Section A "creates the content and context for Section B" (DoE, 2002b:10). Therefore enough time should have been awarded for teachers to consolidate the skills and content in Section A to prepare the learners for Section B. However, according to the teachers this was not the case – there was not enough time and therefore no justice was done to the CTA. It would have made sense that teachers be provided with the CTAs earlier in the year so that there was enough time for formative assessment. It is emphasized that Section B reflects the transfer of skills, and focuses on application, analysis and understanding and does not necessarily focus on the same skills as in Section A. However, from the above comments made by teachers, it is difficult for teachers to separate content and skills. This argument is supported by Ongunniyi (1999) who believed that it is difficult to separate process skills from content when setting test items.

The achieved curriculum, which is partly reflected in the results on the CTA (Section B), reveals that there is an identifiable mismatch of the intentions of the intended curriculum and the implemented curriculum on the one hand and the perceived and achieved curriculum on the other hand. One of the objectives of the intended curriculum is it "strives to enable all learners to achieve to their maximum ability" (DoE, 2002c:1). By striving to do this, performance based tasks which were contextually based were introduced in order to make learning and good performance possible to all learners from diverse social backgrounds (Bansilal, 2008). On the contrary, however, the implemented curriculum (the CTA) did not manage to achieve its objective completely, possibly due to many influential factors such as different SES schools – lower SES schools with larger classes, underperformed; gender differences – females had the edge in answering contextualized questions; language – second language participants underperformed and the design of the CTA – some questions were ambiguous, and too much reading was required which disadvantaged learners from lower SES schools; and insufficient time to do formative assessment – many teachers complained that they had too little time, which meant that for Section A there was not enough time for learners to grasp the skills tested.

The CTA document emphasized that Section B "should assess recall and understanding…" (DoE, 2002b). However, this was not possible in most cases, since teachers, who were busy marking large classes of CTAs (Section A), did not have enough time to review common mistakes and provide positive formative assessment. How could learners recall skills or concepts that were not properly understood? The CTA did not provide a fair opportunity for all learners from diverse social backgrounds and linguistic groups. These findings are supported by those of Bansilal (2008). Although the CTA comprises of 25% of the learners' performance, of which Section A makes up 40% and Section B makes up 60%, it was important since it had been made compulsory for all Grade 9 learners to write the CTA (DoE, 2002b).

The overall mean score on Section B of the 2004 CTA in Natural Science of all 1572 learners was 38.3% which meant that the learners had an average rating of "partially achieved". This is not very promising and further investigations should be done in future on CTAs to see whether or not learners have progressed.

However, the limitations found in this CTA match those described by Gipps and Stobart (1997) who believed that there are always shortcomings in each form of national assessment. Firstly, the specific content decided on by the external examiners was unlikely to satisfy all teachers. The teachers in this study did not necessarily view the content as a problem but felt that the level of questioning, was not appropriate for Grade 9 learners and that the content should be made more specific at the beginning of the year so that teachers would have more time for consolidation. However, supplying teachers with the exact content to be assessed could inevitably lead to teachers only teaching a certain section of the syllabus – i.e. teaching to the test and leaving out other important sections. This view is supported and argued by Shepard (2000) and Whitford and Jones (2000).

Secondly, the assessment criteria were limited since there were other possible logically correct answers. This seemed to reduce the consistency in marking these tests. This was noted by one of the teachers who stated: "You do need consistency, but if you are going to ask for that sort of consistency in your answers you also have to have the same sort of consistency in your syllabus in terms of detailing exactly what must be taught. You can't have the syllabus open-ended but have your answers very restricted".

Thirdly national tests are only a partial form of assessment and therefore should be used cautiously. In this study the CTAs counted 25% towards the final mark, of which 40% consisted of Section B and 60% consisted of Section A. The classroom continuous assessment counted 75%. Although Section B only contributed 40% towards the CTA mark (which is 25%), it carries great value since it is part of the validating tool for CASS and reflected any shortcomings in teaching and learning.

Different cognitive competences were also reflected in the CTA questions. Using Green and Naidoo's (2006) method of classification, which originated from Verhage and de Lange (1997), it was easy to categorize some of these competences based on the process skills which were identified. After analyzing the results, it was evident that the middle level complex cognitive competences featured more prominently than metacognitve, advanced and simple cognitive competences. This was reflected by certain identified process skills; e.g. apply, make decisions, communicate, analyze, interpret and conclude. These skills are mainly assessed by "free response" questions (DoE, 2002b:16). The higher level advanced cognitive competence and simple cognitive complex featured to a lesser extent. According to this analysis, the CTA consisted of complex questions that required middle level complex cognitive competences.

From the overall mean score, which was only 38,3%, it seems that the majority of learners only "partially achieved" (DoE, 2003a). This meant that many learners hesitated with the middle cognitive competence level questions and this may be a major concern in science education. At present one of the purposes of the CTA is to promote a common standard. With the majority of learners in South Africa, speaking a language foreign to the test and having problems understanding the style of questioning, especially at this level, the CTA test would seem unfair to the majority of learners. According to Verhage and De Lange (1997:15) this middle complex cognitive level required learners to "relate two or more concepts or procedures" and there is always more than one approach to a problem, i.e. more subjectivity than objectivity is required in this level. This style and level of questioning in the CTA can explain why learners who were average and below average battled with most items, since most of the items referred to the middle complex cognitive level.

An interesting finding which showed a strong link between different SES schools and levels of achievement (see fig 4.20) needs to be further investigated to find out why learners from low SES schools perform poorly on these tests. This study is a typical example of Vygotsky's (1978) perception of learning as a form of interaction. Is there a link between the cognitive competence levels of learners from different SES schools? One should, however, be cautious to use these findings since many other factors have also contributed towards the learners' performances.

CHAPTER 5

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

Since the time when the first CTAs were partially introduced at some schools in 2002, according to Dr. Zoleka Sokopo (Assessment Coordinator at the time), only three known formal studies have been conducted on them. Firstly, a report compiled by Wilmot (2004) described the Development Phase of a two-year collaborative research and curriculum project, which focused on the Grade 9 Learning Area of Human and Social Sciences (HSS). The report contained a detailed analysis of the Department of Education's Assessment Guideline document (DoE, 2002) and an evaluation of the CTA for HSS which was implemented at two selected schools in 2003. It provided evidence suggesting that the 2003 HSS CTA was a significant improvement on the one previously implemented at the schools in 2002, particularly in terms of the quality of the source materials included in the CTA and assessment (Wilmot, 2004). A second study examined the overall implementation of the CTAs and CASS (continuous assessment) in 1500 schools across the nine provinces. This was conducted by the Khulisa Management Services on behalf of the DoE in conjunction with the Independent Examinations Board (IEB) in 2004 (see Chapter 2 pages 62-63). Recently a third study was conducted by Bansilal (2008), which identified learners' experiences of the Mathematics CTA of 2004 and the disjuncture between the intended and the perceived curriculum. However, neither of the above studies focused on an in-depth study of the Natural Science CTA – which the present study attempted to do.

This chapter presents the final stage of the thesis by providing the conclusions, possible implications and recommendations of the research. The investigation was designed to answer various questions listed in Chapter 1. The research questions are answered in the order they appear and, after each answer, a brief conclusion is reached and possible recommendations and inferences are made for teachers, curriculum planners and policy developers.

The purposes or goals of the research were:-

- to identify any concepts in the 2004 Natural Science CTA test items with which 1572 conveniently sampled learners recorded difficulty when answering;
- to identify any process skills in which this fairly large and representative sample of the learners underperformed as a group;
- to assess whether the CTA test paper as a whole might be considered as too easy, too hard, or at a reasonable level of difficulty;
- to detect whether misconceptions or misinterpretations were evident in the learners' responses to individual test items in the Natural Science CTA;
- to measure differences in CTA performance between groups in terms of selected independent variables such as gender, level of socio-economic status (SES) and home language;
- to detect whether there were possible shortcomings in the design of the CTA itself – for example, with regard to layout, ambiguity, clarity, appropriateness for RNCS (2002c) and diagrammatic representation; and
- to make evidence-based recommendations for the possible future use (or possible discontinuation) of CTAs in Natural Science at the Grade 9 level.
- to record, analyze and explain problems encountered by local schools; and possibly,
- to discuss and evaluate the soundness of selected national curriculum statements.

5.2 **Research question no.1:** How did a sample of 1572 learners and their teachers experience the 2004 Grade 9 Natural Science Common Tasks for Assessment (CTA), Section B, as a potential instrument of performance and educational achievement?

5.2.1 Conclusion

About three quarters of the sample of interviewed learners reported that the questions in the CTA were different from those with which they were familiar with in the classroom. Four main differences mentioned were: the new style of questioning adopted in the CTA (based on real life situations); the novel language format used in the CTA (too long winded); certain questions in the CTA also involved more problem solving skills (which required more time for reading and conceptualizing); its vagueness (which made it difficult to understand) and too little time for teachers for feedback and consolidation.

Overall the responses from these learners generally appeared to imply that the CTA had a different, sometimes unfamiliar, style of testing compared to a traditional class test.

All of the interviewed teachers said they believed that the CTAs should be continued but that they should have been given sufficient time to teach the CTAs thoroughly. Also emphasised was the need for the curriculum to be more specific in relation to sequencing content so that there is consistency in teaching and achievement levels required among schools.

All of the interviewed teachers identified **time** as a factor that hindered their ability to do justice to the CTA. It seemed that there was not enough time for CTA consolidation since teachers had to do other administrative work.

Several reasons suggested that the CTA test might have been partly "unfair". These were: the complexity in the language used - especially for the Xhosa-speaking learners; and the incorrect grammatical translation of the CTA into Afrikaans. Although the CTA attempted to relate problems to a "real-life" situation by developing a particular context, which many learners and teachers acknowledged, it created problems for many learners. These contextualized questions disadvantaged many learners because they were not familiar with the style of questioning; too much reading created a problem for learners who used English as their second language and the weaker learners, which were revealed in the interviews.

During the interviews it became apparent from the responses that certain items in the test discriminated between learners of average and lower achievement and seemed to advantage the above average learner. Also they may have disadvantaged the learners who came from a non-English background.

The majority of learners interviewed seemed to have found the CTAs different and of a higher standard to that of classroom work (which made it difficult to understand) (see page 158).

During the interviews it seemed that the criterion to "strengthen the capacity for school-based continuous assessment" stated in the RNCS (DoE, 2002c:79), was not satisfactorily met due to limited time. Continuous assessment was described as that which covered all the necessary aspects for OBE educational assessment. However it seemed that formative assessment as emphasized in the RNCS (DoE, 2002c) did not occur because the teachers were not given sufficient time for proper teaching, learning and formative assessment, which were crucial.

With regard to ensuring "consistency in teacher judgments" (DoE, 2002c:79), this was reported to be partially achieved. The argument for it being partially achieved was based on the fact that standard assessment criteria were issued to all teachers to use. Contrary to this argument was the "mismatch between policy intention and policy practice" Sayed (2002:29); which was stated by one teacher:

> *"...if you are going to ask for that sort of consistency in your answers you also have to have the same sort of consistency in your syllabus in terms of detailing exactly what must be taught. You can't have the syllabus open-ended but have your answers very restricted".*

The mean score for 1572 learners' overall performance (i.e. their test totals) revealed that learners had an average rating of "partially achieved" according to the level descriptor codes described in the South African National Education Policy Act (DoE, 2003a). Furthermore, the fact that 23% of learners scored less than 11 out of 80 should be regarded as a major concern to teachers and curriculum planners, if their focus is on the learners' attainment of basic levels of achievement. Besides the many factors that could have influenced the learners' performances, the questions in the CTA seemed to have been very challenging.

5.2.2 Implications for teaching and learning

It is clear from the above conclusion that the CTAs are different from class work and the style of questioning disadvantaged second language participants. This was also found in one other study (Bansilal, 2008). It seems to be accepted and acknowledged by some teachers (in this study) as a potential instrument of performance and educational achievement. However, it does not fall short of criticisms which need attention. Curriculum planners should be sensitive to the needs of teachers since the CTA is a new form of assessment and should encourage teachers rather than discourage them. Although the aim of the CTAs is not to test content but skills, it is difficult to separate the two (Ogunniyi, 1999). Therefore, content should be more explicitly outlined in the RNCS document as mentioned in past studies on the CTAs (DoE, 2004c) so that there is consistency in teaching and achievement levels required among schools.

In the present situation, where science teachers are few and teachers are teaching science with no science background, it does create a problem if the curriculum is not explicit enough.

The study revealed that too little time was provided for learners to complete test and teachers to consolidate work based on the CTA. At present CTAs are arriving at varied times and this creates added stress for teachers who want to have sufficient time to work through the CTAs. The policy document on the CTAs suggest that the CTAs be written in the fourth term (DoE, 2002b:8). As a teacher, I have witnessed that during fourth term, teachers are tired and loaded with administrative work, which results in inadequate preparation, time and effort for justice to be done to the CTA. This was also found in other studies on CTAs (DoE, 2004c).

The CTA policy document emphasizes that Section B "assesses individual competence and will focus on selected specific outcomes and skills…" (DoE, 2002b:11). This study has revealed that the CTA has included these skills, outcomes and certain level of competences. However, the results of this study clearly show that the learners found the CTA very difficult and of a high standard as before (DoE, 2004b). Since the questions of the CTA are contextualized, problems associated with limited time and language of the test would remain obstacles as found in studies done by Bansilal (2008). This implies that the problems associated with the CTAs implementation needs to be addressed. If no real attempt is made to improve the time factor involved with the CTAs management (time of delivery to schools) and style of questioning, teachers and external examiners will simply continue in the manner they had before and the CTA will become a waste of paper and effort. If teachers are rushing to get through the CTA in the fourth term, justice cannot be done to the CTA and learners will be losing out on proper learning as mentioned earlier by one teacher (page 161).

5.3 Research question no.2 Why did the learners perform in the ways that they did, and what deeper insights into the learners' achievements on the CTA were gained when their responses/results were analyzed?

5.3.1 Conclusion

Some of the possible aspects that may have impacted on the low performances of learners were misconceptions, misinterpretations, lack of prior knowledge, language and comprehension skills and graphing skills. These possible aspects have also been identified in previous studies (Arnold & Millar, 1994; Cohen, Eylon & Ganiel, 1983; Colyn, Hasson & Morrison, 2001; Duit & von Rhöneck, 1998; Freddette & Lockhead, 1980; Hendricks, 1999; Mammino, 2002; Psillos, Koumaras & Tiberghien, 1988; Sadeck, 1999; Sadeck & Scholtz, 2003; Shipstone, 1985b; Stanton, 1990).

Shortcomings with regard to the wording and composition of each item; clarity; length; layout; degree of abstraction; ambiguity; certain items were inappropriate for Grade 9 learners; and diagrammatic representation may also have had an influence on their performances. Another factor was time constraints - too little time for section A to have been taught thoroughly in 2004 and little time for consolidation of concepts.

The language used in the CTA was difficult for learners who spoke English as a second language. The test appeared to have discriminated against Xhosa learners and this was especially evident in their written responses to questions and basic grammatical language errors. There were also highly significant differences between Xhosa, Afrikaans and English learners on the mean scores of 24 of the 25 items. In the majority of items, English learners performed better than Xhosa and Afrikaans learners. In some respects the manner in which the CTA was translated from English into Afrikaans was seriously defective. Furthermore, many of the interviewed learners felt that the questions given in the CTA were very different from what they had been exposed to in class work in terms of the language format, its vagueness and the fact that more problem solving skills were required in the CTA.

Another reason for learners' poor performances is the unusual style of questioning combined with more middle and "higher order analytical skills" (DoE, 2002b:16). Many learners revealed that they were not used to these type of questions.

There was a highly significant difference between the performances of males and females in the total score of the Science CTA, where females performed better than males

It appeared that the females scored better on science process skills like 'decision making', 'drawing conclusions' and 'justifying an argument' whereas males scored better in 'constructing and interpreting diagrams', 'identifying variables', 'applying knowledge' (balancing equations) and 'translating a graph into a table'.

5.3.2 Implications and recommendations for external examiners

It is very clear that there will always be certain factors that contribute to learners' performances, either in a negative or positive way. However the CTA has proven to be a tool to highlight these troubled areas that need attention. For example: misconceptions or lack of certain concepts can be revealed. The idea of the CTAs is not discouraged but the manner in which it has been implemented should be carefully revised.

The CTA should be thoroughly checked with regard to language (from English to Afrikaans), ambiguity and other shortcomings before issuing it to the schools. It should also be checked for gender bias, type of skills tested, and style of questioning and try at all times to establish a good balance in style of questioning.

5.4 Research sub-question no.1: On which of the 25 items in Section B of the 2004 Grade 9 CTA in Natural Science did the mean scores for the combined sample of 1572 learners from 12 schools, taken as a whole, meet or exceed the specified minima for acceptable levels of performance?

5.4.1 Conclusion

Among the 25 items tested, acceptable levels of achievement (decided upon by a panel of experienced teachers) were attained on only nine items. The particular items in which learners performed the worst were based on the process skills 'identifying and controlling variables' and 'interpreting graphs'. These results were strongly consistent with the findings of Sadeck (1999). This might mean that they were unable to deal with the cognitive demands of the question which was classified under a high level advanced cognitive competence, i.e. scientific investigation (Green & Naidoo, 2006). Further elaboration on the process skills are explained in section 5.8.2 (page 212).

5.4.2 Recommendations for teachers

Teachers should place emphasis on these particularly problematic 'process skills' and possibly improve lessons by using a variety of teaching approaches. These skills are also taught in mathematics. For a follow up study it might be recommended to investigate whether learners do well in these process skills in mathematics (where traditionally it is taught "out of context") – whereas in science the process skill has to be applied within a specific context.

5.4.3 Implications for teacher training

Since great emphasis has been placed on process skills, it is important that science teachers are able to comprehend and interpret the policy document, and also to know what procedural steps are required for each skill, as they will be expected to implement it in their classrooms. Therefore it is implied that the requirements and explanations of these skills be included in teacher training programmes; for example, "the use of self-questioning by pupils in developing their process skills in science" as described by Chin (2006:113). With regard to teaching the notion of variables, the following questions could be asked during regular classroom lessons (Chin, 2006:116):

- What are the variables involved here?
- What is the relationship (direct, inverse or none) between variables A and B (e.g. for tables, charts and graphs)?
- What pattern and trend do I see here (e.g. for tables, charts and graphs)?

5.4.4 Implications for curriculum planners

Cognisance may be taken of the possible factors that could be the cause of the poor item performances of learners, and curriculum changes should be made accordingly to some of the CTA science items in order to possibly improve learners' performances. Also, teaching strategies could be made more explicit in the RNCS by providing guided information on the specified process skills by recommending certain textbooks or teaching websites to teachers.

5.5 Research sub-question no. 2: Were the learners' misconceptions in knowledge and skills found to be similar to those already known in the published literature; and did there appear to be any misinterpretations of certain questions when representative samples of English-speaking, Afrikaans-speaking and Xhosa-speaking learners had their CTA answers scrutinized in depth through interviews with teachers and learners, as well as their scripts?

5.5.1 Conclusion

Although misconceptions were not the main feature of this study, nevertheless in any form of assessment misconceptions do arise. An analysis of learners' scripts in this study revealed certain misconceptions that could have resulted in the poor performance of some learners. However, after examining the learners' scripts, it became apparent that not all incorrect answers were necessarily the result of learners' misconceptions but possibly occurred as a result of misinterpretations and lack of prior knowledge.

Certain misconceptions that were evident were based on electricity and chemistry. They have also been noted in earlier literature, e.g. Hendricks (1999); Mammino (2002); Shipstone (1985b) and Stanton (1990). With regard to electricity, learners misrepresented the circuit diagram by drawing light bulbs, ammeters and voltmeters instead of using the symbols representing each part. It was assumed that learners had been taught how circuits are represented scientifically. Another common misconception or area of ignorance was presenting one cell as a battery instead of two. With regard to the chemistry section, a common misconception was that the formulae of substances can be changed. For example, many learners falsely believed that the water molecule H_2O could have been written as H_4O_6. According to the "law of definite proportions" this is not allowed, since each substance has its own standard formula that cannot be changed, as discussed earlier (Chapter 4, page 139). Many learners seemed to lack certain concepts with regard to prior knowledge in physics. For example, the concept of 'voltage' had not been mentioned in the Grade 9 Revised National Curriculum Statement (DoE, 2002c) but it has been referred to in the Grade 10 syllabus. This seemed to result in a large disparity in performances among learners from various schools who were not familiar with the concept.

5.5.2 Recommendations for teachers

The findings indicate that at a given age level, certain misconceptions or areas of scientific ignorance are very persistent, bearing in mind the findings reported in past international studies. Therefore, eliciting these misconceptions and misinterpretations in the classroom, so that teachers are made more aware of them, may be helpful.

5.5.3 Implications for teachers

Teachers might be encouraged to use imagery in teaching chemical formulae, which has been proved to be a useful tool (Mammino, 2002). Also, before continuing with a new section, more time might be spent on teaching certain basic concepts in electricity, e.g. the difference between a cell and a battery; and the representations of circuit diagrams and symbols, so that learners could first get to grasp very simple concepts that seemed to surface quite persistently.

5.5.4 Implications for teacher training

If future science teachers are made aware of these details and other knowledge gaps and misconceptions, they may be better equipped to develop lessons that might counteract or reduce these misconceptions.

Misinterpretation of science text can also occur as the result of a language deficiency. Teachers should be made aware of this and it is suggested that they might be specially trained to overcome or reduce the language barrier in science teaching.

5.5.5 Implications for curriculum planners

The RNCS document might be made more "teacher friendly" in future with emphasis to be laid on basic content knowledge required by learners before entering the FET phase. A stronger link might be established between curriculum planners and educational researchers with regard to definitive basic knowledge. Furthermore, an updated list of misconceptions in each topic might be published annually and distributed to schools and included as a section in a teaching guide. Many discovered misconceptions may have arisen through research, which teachers are not particularly aware of. Knowledge of these misconceptions could be of great help to novice teachers studying the new syllabus.

5.6 Research sub-question no. 3(a):

Did the in-depth interviews conducted with the selected teachers and learners reveal possible short-comings in the wording and composition of each one of the items 1 to 5 (e.g. in respect to clarity, length, layout, degree of abstraction, sequencing, weighting, appropriateness for RNCS (DoE, 2002c), ambiguity and diagrammatic representation?)

5.6.1 (3a) Conclusion:

The in-depth interviews revealed that some of the questions asked were not very clear – it was vague and learners needed more time to read it. The CTA was quite long and required a lot of reading and therefore sufficient time was needed, which was in this instance not provided.

The questions based on the graphs were not very well presented. All the graphs were not displayed on one page and this created confusion with some learners. According to a teacher, many learners only studied the graphs on which the questions were presented and ignored the other graph.

It was noted that the examiners attempted to make the CTA test less abstract and more interesting by providing pictures. However, some learners seemed to find the straight line graphs more abstract than the bar graphs and therefore might have required a deeper understanding of how the numbers on the axis relate to each other and to the line on the graph in order to answer questions.

When analyzed by a group of teachers and a subject advisor, it was revealed that most of the process skills stipulated in the RNCS (DoE, 2002c), were tested in the CTA (Section B). Also, many learners thought that the questions were based on real life situations and had much relevance attached to them. However, many of them found these contextualized questions to be difficult due to various reasons described later.

Certain questions were regarded as being ambiguous (page 163). The weighting of marks according to certain questions were also criticized (page 146 and page 147).

5.6.2 (3a) Implications for curriculum development and implementation

In order to maintain **consistency** in the implementation of a curriculum in the classroom, certain science concepts to be taught should be made more explicit in the RNCS (DoE, 2002c) document so that all teachers have a clear idea as to what are the minimum skills requirements for a Grade 9 learner. At present the document is not very specific in terms of scientific content and concepts, due to the foundational premise of OBE. However, it is important that teachers receive the necessary guidelines in order to ensure consistency across schools. If the external examinations should be conducted in future in a similar fashion, then it is important that the teachers be given enough **time** to practice formative assessment with their classes, which seemed not to have been done successfully in the implementation of the 2004 CTA.

5.6.3 (3a) Recommendation for improvement of the CTA

Preliminary shifts in the content of any future CTA should be checked by specialists in the field to minimise any shortcomings in the test, e.g. ambiguity, incorrect translations from English into Afrikaans, levels of difficulty, adequate time allocation and incorrect labelling of axes that reduced the quality of the test.

5.7 Research sub-question 3(b):

Did the in-depth interviews produce triangulating evidence that clearly illuminated, explained, corroborated or amplified the empirical findings presented as answers to the research sub-questions 1 and 2?

5.7.1 (3b) Conclusion

The in-depth interviews produced sufficient evidence that substantiated the empirical findings presented as answers to the research sub-questions 1 and 2. Especially with regard to their poor performances in certain questions. The responses from interviews seem to explain the poor outcomes: learners complained about the graphical questions – they found it difficult to read off the dots from the graph; the straight line graphs confused them and they were not familiar with such graphs. Evidence of poor understanding of questions reflected in their answers were explained by the learners as difficulty in understanding the text (language problems) the style of questioning (contextualized questions) and ambiguity (page 163). This was particularly evident with the Xhosa learners and weaker learners. Questions in which they performed very poorly in (identifying variables), were claimed by some learners as not been taught in class. Also, the poor performance of learners on graphs (item 5, page 144) and symbolic representations in chemistry (item 4.1, page 138) were explained by the teachers as work not appropriate for Grade 9 learners. The above average learner had no problem answering these questions but the average and below average learner responded incompletely.

5.8 Research sub-question 3(c)

To what extent did the CTA cover process skills, Learning Outcomes and Assessment Standards?

5.8.1 (3c) Conclusion

The consensus reached by a group of experienced and qualified educators who analyzed the science content of the CTA identified the following process skills:

Interpreting information: this skill was tested strongly on the majority of items apart from items 1.1, 1.2, 1.3, 2.8, 3.3 and 4.1(b).
Decision making: was tested on items 1.2, 1.3 and 1.4.
Recalling meaningful information: was tested on items 1.1, 1.2, 1.3, 3.1, 3.2 and 4.1b.
Communicating science information: was tested on items 1.1, 2.8, 2.9, 4.2a, 4.2(b)1, 4.2(b)2, 4.2(b)3 and 5.
Drawing a conclusion: was tested only on item 2.9.
Observing and comparing: were tested only on item 1.4.
Sorting information: was tested only on items 3.1 and 4.2(a).
Recording information: item 2.8
Planning science investigations (describing and controlling variables): was tested on items 2.1, 2.2, 2.3, 2.4, 2.5, 2.6 and 2.7.
Hypothesising inferred: items 2.2 and 2.4.
Evaluate information: items 4.2b1, 4.2b2, 4.2b3 and 5.
Raising questions about a situation: was tested on item 2.6.
Problem solving: was tested on items 3.1, 3.2 and 3.3.
Applying knowledge: was tested on items 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8 and 2.9.
Justifying an argument (scientific reasoning): was tested only on item 3.4.

The analysis by collegial agreement of the items in the CTA revealed that '**interpreting information**' was involved in almost all of the items.

Consensus reached by experienced science teachers revealed that all three LOs were covered by various items to a certain degree. It appeared that LO2 had been tested to a greater extent than the other two LOs. It seemed that all Assessment Standards were applied, except for 'categorising information' which was not identified. 'Interpreting information' was an Assessment Standard that seemed to have appeared the most.

5.8.2 (3c) Implications for the content of the CTA

These findings imply that 'interpreting information' – which is an 'integrated' or 'higher order' process skill (Beaumont-Walters & Soyibo's, 2001) – was very pronounced in the CTA and it relied upon more sophisticated cognitive abilities such as organizing and evaluating information (Green & Naidoo, 2006). It seems that the CTA mostly encouraged the use of higher order skills.

These findings also imply that each one of the items was able to encourage and measure a process skill. Eleven out of the 25 items measured at least three process skills simultaneously (see Appendix 1).

The CTA encouraged the practice of mostly middle and higher level skills which were represented by complex cognitive, meta-cognitive and advanced cognitive competences using Green and Naidoo's frame of competence.

The middle level complex cognitive competences tested were: applying knowledge, decision making, hypothesizing inferred, communicating science information, interpreting information, evaluating information and drawing a conclusion.

The highest level meta-cognitive and advanced cognitive competences were: justifying an argument (scientific reasoning), scientific enquiry, raising questions about a situation, problem solving and planning science investigations (describing and controlling variables).

The lowest level simple cognitive competences tested were: observing and comparing, recalling meaningful information and sorting information.

It also seemed that learners performed with varying degrees of success in certain process skills when applied in different questions. For example, learners performed better in items 3.1 and 3.4 compared to items 2.9, 4.1(b) and 5. The former items required learners to interpret text and the latter items required an interpretation of tables and graphs. Did competence in this skill vary as the nature of the information varied? In other words, by implication, was 'interpreting information' context-dependent?

The content of the CTA seemed to have covered a wide variety of process skills with an emphasis on the middle and higher level competences. The findings imply that the levels of competence required by some items were rather high; and that certain process skills, Assessment Standards and LOs might have been more prevalent than others; and that it might not have been easy to design a well-balanced test. An implication that is of potentially great significance for any future CTA development and implementation is the possibility that teachers, who are specialists in the field of study, will be able to reach consensus in identifying the particular process skills, LOs and Assessment Standards tested, hence mirroring what was done by the researcher and experienced teachers in the present study. However, it should be noted that this procedure took time and reaching consensus was not always easy.

5.8.3 (3c) Implications for teachers

Classification of the nature and varied levels of cognitive competences, as described by Green and Naidoo (2006), should be studied by teachers in order for them to realize the levels of their lessons and assessment with regard to cognitive competences. They could be encouraged to develop lessons which include a variety of process skills that fall under the middle-to-higher competence levels so that their learners can become more familiar with these types of questions. Since it is beyond the scope of this study to produce teaching strategies that could improve learners' proficiency in certain process skills, it is suggested that these skills be taught and that it not be expected of learners to grasp them automatically.

5.8.4 (3c) Implications for curriculum planners and textbook writers

Curriculum planners could be invited to outline the different levels of learner competence in the Grade 9 teacher's manual, alongside the process skills, so that teachers will have some kind of background knowledge about these theories. Curriculum planners are assumed to be aware of the level of competence they anticipate for a Grade 9 learner and therefore they should be more explicit in policy documents as to what minimum requirements are expected from a Grade 9 learner. For example: the Grade 9 curriculum for Natural Science (DoE, 2002c:45) states that:

> By Grade 9, most learners are able to see that certain quantities are constant even when change takes place…; the learner can think through more complex problems without actually doing them, provided pictures or models are available to work with…; the language of the learner has developed so that an increasing number of relational concepts can be used and understood…; by Grade 9 some abstract thinking is taking place.

Perhaps the further development of a textbook for Grade 9 teachers could be more specific in details and provide examples for teachers. It can be argued that teachers should be motivated to develop these examples themselves; but the reality is that many teachers may not have the expertise, time or motivation. According to Reddy (2006b:412):

> …. given the problems of teacher shortages and teaching quality, it is important to consider providing high-quality structured learning materials (for example, textbooks) to learners. Structured learning materials, especially in poorer learning environments, can provide a fail-safe mechanism for learners to acquire knowledge. Given that the nature of mathematics and science knowledge is cumulative, the structured learning materials can provide a way of to acquire this knowledge even if there is no teacher.

5.8.5 (3c) Recommendation for further research

Research could be done on how early in the primary school certain complex skills could be introduced and used. For example: can complex skills, like hypothesizing, be introduced in simplified forms even from the Foundation Phase? How early can the skill be developed?

5.9 Research sub-question no. 4(a):

When the 12 sampled schools were grouped into four bands according to SES (three highest SES, three second-highest SES, three third highest SES and three lowest SES), did the levels of the 12 CTA average scores (totalled out of 80) correspond uniquely with each of the four bands?

5.9.1 (4a) Conclusion

The findings have suggested that schools from similar socio-economic backgrounds produced more or less similar CTA mean scores.

5.10 Research sub-question 4(b)

Were there significant differences between the mean total CTA science scores of the four bands of 12 schools grouped according to their SES?

5.10.1 (4b) Conclusion

There were significant differences among the mean scores between the schools from different levels of SES, especially between the highest and lowest level SES schools which revealed a highly significant difference in mean scores. The results displayed a distinct pattern in the levels of achievement in the order: highest SES > medium SES > normal SES > lowest SES.

5.11 Research sub-question 4c:

Did the high level SES schools perform better than the lower level SES schools on all 25 items in section B of the 2004 CTA examination in Natural Science?

5.11.1 (4c) Conclusion

The high level SES schools performed better than the lower level SES not on all the items but the majority of items. The distinct pattern was evident for 16 out of the 25 items.

5.12 Research sub-question 5a

Was there a significant difference between the total achievement score totals of the 912 females and the 660 males on the 2004 Grade 9 Natural Science CTA?

5.12.1 (5a) Conclusion

There was an astonishingly highly significant difference of 7.6% between the performances of males and females, with a very high F-ratio of 47.7.

5.12.2 (5a) Implications for intervention action

A literature review revealed the finding that the level of performance of learners can be influenced by the nature of their socio-economic backgrounds (HSRC, 2005; Reddy, 2006b; Riddel & Nyagura, 1991; Rothman, 1997).

The current findings and results imply that, although the schools from a similar socio-economic background seemed to perform similarly on the CTA, the achievement gap between the highest and lowest SES schools was disturbingly evident, implying that additional policy and administrative intervention input might occur at the lowest SES level schools as a priority.

5.12.3 (5a) Implications and suggestions for researchers

Attwood (2003:249) stated that, "although very little can be done (by the school) to improve learners' socio-economic status, something can be done to improve their mathematics performance" - or, in this case, science-performance. Literature, based on external examinations which used systemic assessment, has revealed strategies to be used in dealing with under-achieving schools (Tell, 1998). For example, if schools were categorized according to their socio-economic backgrounds, the schools that were under-performing within their category could be investigated and assisted in order to improve their future performance. Learners whose science score totals were above average (60%-100%) and who attended low SES schools could be interviewed to find out what they were doing differently from the other learners who were under-performing (Attwood, 2003).

Other schools that were performing well under similar conditions could also be investigated and supported in order for them to maintain their standard (Malcolm, Keane, Hoohlo, Kgaka & Ovens, 2001; Tell, 1998). This form of strategy has also been mentioned by the Provincial Minister of Education and Culture in the Western Cape, Cameron Dugmore (Mangxamba, 2006:1-2). Although there are contrasting views on this forthright recommendation, as discussed in Chapter 1, it seems to justify the use of an external examination as a stimulator of progress.

5.13 Research sub-question 5b

Were there significant differences between the achievement scores of the 912 females and the 660 males on each one of the 25 items of the Grade 9 Natural Science 2004 CTA?

5.13.1 (5b) Conclusion

The results in Table 4.9 (page 177) indicate that there were many highly significant differences in achievement between males and females. The females attained a significantly better mean score than the males on 20 of the 25 items. However these highly significant differences were evident among the highest SES schools only. It appeared that the females scored better on process skills like 'decision making', 'drawing conclusions' and 'justifying an argument' whereas males scored better in 'constructing and interpreting diagrams', 'identifying variables', 'applying knowledge'(balancing equations) and 'translating a graph into a table'.

5.13.2 (5b) Implications

It is quite evident that gender differences in performances do prevail. However it could be argued that this depends on the type of assessment and its context. It has been stated that Section B, being a paper and pencil test could be designed by "using objective and or free response questions" (DoE, 2002b:16). The CTA used mainly free response questions as identified earlier (page 196). This seemed to indicate that females were possibly better in expressing themselves than males since the CTA questions were not very straightforward in nature, and they required learners to express themselves more comprehensively. For most of the items tested, females outsmarted the males.

5.13.3 (5b) Recommendations for external examiners

External examiners should take note of the difference in performance of males and females in the CTA. Although it is stated that Section B could include "objective and/ or free response questions" (DoE, 2002b:16) – more 'free response' type questions were asked. These results seem to reveal a bias against male learners. It could be recommended that more objective tests, *viz.* multiple-choice questions, true/false questions or matching could be included in the CTA. This required a writing style to be more short and factual whereas extended reflective writing improved girls' marks more (Elwood & Comber, 1996; Howie, 2001).

5.14 **Research sub-question 6a**:

Were there significant differences among the total achievement scores of the Grade 9 Natural Science CTA between Xhosa -, Afrikaans - and English-speaking learners?

5.14.1 (6a) Conclusion

Statistically there was a highly significant difference between the achievement scores of learners when grouped according to their home language. According to the descriptor codes (DoE, 2003a), only the English learners achieved and the Xhosa and Afrikaans did not achieve.

5.15 Research sub-question no. 6b:

Were there significant differences in academic achievement among Xhosa - , Afrikaans - and English – speaking learners on each one of the 25 individual items of the Grade 9 Natural Science CTA 2004?

5.15.1 (6b) Conclusion

The findings presented in Table 4.11 indicate that there were highly significant group differences between Xhosa, Afrikaans and English learners on the mean scores for 23 of the 24 items. . Again, learners had to express themselves clearly and it seems that many learners who spoke English as their first language performed better than learners who were Afrikaans- and Xhosa-speaking.

5.15.2 Research sub-question no.6c:

Were there significant differences among Xhosa- , Afrikaans- and English-speaking learners on the total mean CTA score when sub-grouped according to their SES?

5.15.3 (6c) Conclusion

English second language participants at higher SES schools achieved significantly higher scores than those English second language participants who attend lower SES schools. English second language participants from high socio-economic status schools also attained better mean scores than English first language participants from a lower SES.

5.15.4 (6c) Implications

Although Xhosa learners achieved significantly lower scores compared to the English and Afrikaans learners, these findings strongly suggest that the schools' SES has an influence on second language participants' performance.

5.15. 5 (6c) Recommendations

The Department of Education should continue to monitor the performance of the different types of schools as done by this study. Remedial assistance should be provided to those schools who are under-performing. Further investigations might be conducted on these low SES schools to determine ways and means to improve learners' performances.

5.16 Research sub-question no.7a:

Were there significant differences between males and females on the total achievement scores of the Grade 9 Natural Science CTA 2004 when sub-grouped according to language?

5.16.1 7(a) Conclusion

The statistical analysis showed that there were no significant differences on the total achievement scores between males and females when sub-grouped according to language.

5.17 Research sub-question no. 7b:

Were there significant differences between males and females on each one of the 25 individual items of the Grade 9 Natural Science CTA 2004 when sub-grouped according to language?

5.17.1 (7b) Conclusion

The statistical analyses indicated that there were no significant differences between the males and females when sub-grouped according to their home language. Although item 2.9 (electricity) did show a significant difference of $p=0.006$, this result might be regarded as spurious since one item out of 20 can be expected to be significant purely due to chance at the $p=0.05$ level of significance, as a general statistical principle.

5.18. Further Discussion

The CTA can be categorized as a standardized test which allows for systemic evaluation. It is a standardized test since it is a common test set for all learners nationwide. It is systemic because it is a tool for monitoring the performance of the education system. One cannot argue that there are many problems associated at present with the implementation of the CTAs, based on the above analysis and past studies, especially in the South African context. These have been revealed mainly as: language and context issues, socio-economic issues, instrumental problems, too little time for teachers to do formative assessment, and learners to grasp certain skills and concepts.

However, one should not judge the implementation of the CTAs too harshly without looking at the advantages. From an administrative or managerial perspective, the CTAs do play a significantly important role which acts as a tool to monitor performances from different schools as shown by this study. However this does raise accountability issues which would be unfair to most schools in South Africa given their circumstances – second language participants, large classes and unqualified teachers. Also, pressure for partly neglected schools to perform could lead to many teachers leaving for better schools where learners are linguistically capable and fairly competent. Another measure that frustrated teachers could resort to is raising the marks of learners, i.e. corruption of marks and teaching only certain skills (teaching to the test). However, the percentages allocated to various assessments – 75%for the classroom continuous assessment and 25 % for the CTA (40% for Section B and 60% for Section A) - seem quite fair and do not lay complete or major emphasis on the CTAs alone.

The CTA's main purpose has been to validate CASS and to assess skills that have been stipulated in the curriculum. In this manner teachers are obliged to teach the skills that have been emphasized in the curriculum, in conjunction with Section A. Teacher classroom assessment cannot be the only means of assessment since it seems to be problematic. Recent studies have revealed that it has not been done properly (Singh, 2008). Therefore, a national form of assessment can be advocated to make sure that certain skills are taught. Also, designing tests which include all the different competence levels, especially middle and higher level competences, could be time consuming for each individual school to do. Thus a number of professionals in education could assist in developing national tests instead of leaving it to individual schools.

Although criticized by many, accountability may be useful in motivating or forcing schools to improve their performance. It is known that schools may develop an adverse reputation and that teachers may possibly lose their jobs; but in which other manner can education be monitored? At present this is only been done in Grade 12. If schools are categorized according to their socio-economic status, as shown in this study, a fair assessment can be made on their performances as done in the United Kingdom (Tell, 1998). This strategy of classifying schools accordingly would refute claims of unfair judgement since, if a school belonging to a certain category outperforms the other similar schools, something positive is happening at that school that should be further investigated. These could be based on a number of factors: either teachers are teaching better or teachers are better qualified or classes are smaller, etc. However, the CTA, being a performance-based assessment should aim mainly at improving classroom learning and therefore should not be used as the only basis for the purpose of accountability.

According to Gipps and Stobart (1997), there are always shortcomings in any national assessment. This study has revealed many shortcomings. However, this is a new form of assessment that has been introduced in South Africa as part of the new education transformation. Therefore it stands to reason that there will be a wide disparity in marks because of the political history and huge socio-economic differences among the schools. However, it can be used in a favourable manner, as agreed upon by all the teachers interviewed, despite all obstacles.

There are many advantages to the CTA as a mode of assessment. Firstly, it can be used to inform learning and teaching. The teachers are made aware of the type of questions to be asked in the CTA, which are basically contextualized questions. However, the emphasis on certain skills, repeated each year, under different context could be improved. A repeat of these type of questions as with previous CTAs, will enable teachers and learners to gain more confidence in the style of questioning.

Although it has been argued by Whitford and Jones (2000) that the improvement of these national performance tests does not guarantee improved learning, nevertheless it does make teachers more aware of improving necessary skills. However, this depends on how motivated teachers are. If learners are not taught the required skills nor provided with sufficient contextualized questions, then the purpose of promoting a common standard setting, which is emphasized in the policy document, will be defeated.

It has been argued that these performance-based assessments disadvantaged low SES learners because of their high literacy levels. However, the mark allocation, which is 25%, is a small value compared to classroom continuous assessment which counts 75%.

These studies show that low SES schools are heavily disadvantaged – most probably due to the fact that many second language participants attend these schools. However these tests should prepare and set a standard for teachers to achieve. Perhaps translating certain difficult words into Xhosa and keeping open ended questions to a minimum will improve consistency in assessment since too much subjectivity could lead to the test becoming unreliable (Whitford & Jones, 2000). In this manner teachers will be kept involved.

Some problems related to the implementation of the CTA, the timing and attitude towards the CTA should change. To overcome some of these problems, it should be given earlier in the year to teachers and should be taught alongside the classroom assessment. Although the curriculum content has not been specified in the United Kingdom our history and context are different. The Grade 9 syllabus should be more specific in outlining content. If these kinds of testing are to be controlled by the state, then the state should be fair to teachers and learners and not test Grade 11 or Grade 12 work at Grade 9 level. Although it is the skills that will be assessed in the CTA Section B, it is very difficult to divorce content from skills, as revealed by the responses of the teachers, and also supported by Ongunniyi (1999). Furthermore, feedback should be supplied to learners immediately before writing Section B, otherwise the purposes of the CTA - as a tool to improve learning and for setting a common standard - will not be accomplished. In other words, there will be a mismatch between the intended and implemented curriculum on the one hand and the perceived and achieved curriculum on the other hand.

5.19 Concluding remarks and final thoughts

I thoroughly enjoyed working on this dissertation. I hope that my work will be read by principals, teachers and curriculum planners. It was interesting doing an in-depth study of learners' responses to CTAs from different schools.

The findings of this study have revealed that CTAs do have a potential place in education, if implemented correctly. If one of the main purposes of the CTA is to maintain a common standard, then further investigations, like the present one, could be performed on a regular basis in order to monitor the performance levels among schools. Although there are problems related to this, as mentioned earlier, teachers are invited to use CTAs in the interest of education, where and when applicable.

This study has also made me aware of the importance of the design and layout of test questions with regard to the quality of a CTA, taking into account gender differences and language barriers. The classification of questions according to process skills, Learning Outcomes and Assessment Standards has provided me, as a teacher, with a better idea of how to set well balanced tests.

> The fact is, when we say 'All students can learn', we should mean it and measure it.
> -- Lisa Keegan (2006), Superintendent of Public Instruction, State of Arizona

The implementation of the CTA has revealed clear differences in learners' performances which differed from school to school. Further conversations with teachers this year have highlighted the idea of 'accountability', where responsible teachers have been questioned about the standard of their work and certain marks given for their tasks. In the past, this form of assessment has been used only in Grade 12. Perhaps teachers will become accustomed to this form of assessment in middle high school and will be kept alert, as mentioned by Tell (1998:66).

Implementation problems that arose with regard to the 2004 Natural Science CTAs were: some marks were too high and needed to be lowered; and work was not properly taught. One of the reasons given for the inadequate standard of work revealed by some of the portfolios was that some teachers were not qualified to teach Natural Science. The introduction of the CTAs in schools may get teachers, heads of departments and principals more involved as teams, instead of working in isolation – which could easily have happened if this form of systemic assessment had not been introduced into schools in recent years.

REFERENCES

Aikenhead, G. (1994). What is STS science teaching? In J.Solomon & G. Aikenhead, (Eds.), *STS education: International perspectives on reform* (pp. 47-59). New York: Teachers College Press.

Ainley, J., Graetz, B., Long, M. & Batten, M. (1995). *Socio-economic status and school education,* ADEET funded project. Canberra: Australian Government Publishing Service (AGPS).

Arnold, M. & Millar, R. (1994). Teaching about electric circuits: a constructivist approach. In R. Levinson (Ed.), *Teaching science* (pp. 49-53). The Open University Postgraduate Certificate of Education. London: Routledge.

Attwood, N. (2003). Relationships between mathematics aggregrate, socio-economic status and gender of grade 8 learners in one economically depressed school situated on the Cape Flats. In M.B. Ogunniyi & K. Rochford (Eds.), *The pursuit of excellence in science and mathematics education. Seminar Series* (pp. 243-251). Cape Town: University of the Western Cape.

Bailey, C. & Smith, A. (2005). Bungle torpedoes final exam: fury over late delivery of tests. Cape Argus, 31st October, p. 3.

Bansilal, S. (2008). Learners' experiences of the CTA. In M. V. Polaki, T. Mokuku & T. Nyabanyaba (Eds.), *Proceedings of the 16th Annual Conference of the South African Association for Research in Mathematics, Science and Technology Education (SAARMSTE).* Maseru: University of Lesotho.

Barnes, M., Clarke, D. & Stephens, M. (2000). Assessment: the engine of systemic curricular reform? *Journal of Curriculum Studies*, *32*, 623-650.

Beaumont-Walters, Y. & Soyibo, K. (2001). An analysis of high school students' performance or five integrated science process skills. *Research in Science and Technological Education, 19,* 133-142.

Bell, B. & Cowie, B. (2000). The characteristics of formative assessment in science education. *Science Education, 85*, 536-553.

Bennett, J. (2003). *Teaching and learning science: a guide to recent research and its applications.* Bath, Great Britain: Bookcraft.

Ben-Zvi, R., Eylon, B. & Silberstein, J. (1986). Is an atom of copper malleable? *Journal of Chemical Education, 63*, 64-66.

Black, P. (1990). Assessment of Performance Unit (APU) science: the past and the future. *School Science Review, 72,* 13-28.

Black, P. (1998). Testing: friend or foe? theory and practice of assessment and testing. London: Falmer.

Black, P. (1999). Assessment, Learning Theories and Testing systems. In P. Murphy (Ed.), *Learners, learning and assessment* (pp.118-134). London: Paul Chapman Publishing.

Boaler, J. (2003). When learning no longer matters – standardised testing and the creation of inequality. *Phi Delta Kappan, 84,* 502-506. Retrieved February 25, 2008, from http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=9225020&site=ehost-live

Bowen, M, G. & Roth, M.W. (1998). Lecturing graphing: what features of lectures contribute to student difficulties in learning to interpret graphs? *Research in Science Education, 28,* 77-90.

Brink, P. & Jones, R.C. (1984). *General Science: Standard 6.* Cape Town, South Africa: Juta and Co.

Cape Argus. SMS The Argus. 2005. 15 November, p.18.

Carmichael, P., Driver, R., Holding, B., Twigger, D. & Watts, M. (1990). *Research on children's conceptions in science: a bibliography.* Leeds, UK: University of Leeds.

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction*, *8,* 293-332. Retrieved July 21, 2007, from http://www.jstor.org/stable/3233596

Chin, C. (2006). Using self-questioning to promote pupils process skills thinking. *School Science Review, 87*, 113-122.

Cohen, B., Eylon, B. & Ganiel, U. (1983). Potential difference and current in simple electric circuits: a study of students' concepts. *American Journal of Physics*, *51,* 407-409.

Cohen, L., Manion, L. & Morrison, K. (2003). *Research Methods in Education.* London: Routledge.

Colyn, M., Hasson, M. & Morrison, K. (2001). *Maths for Africa: Grade 8 learner's book.* Cape Town, South Africa: Juta.

Condy, J. (2006). *The development of an enabling self-administered questionnaire for enhancing reading teacher's professional pedagogical insights.* Unpublished PhD thesis. Rondebosch: University of Cape Town.

Cooper, B. & Dunne, M. (1998). Anyone for tennis? Social class differences in children's responses to national curriculum mathematics testing. *The Sociological Review*, *46*, 115-148. Retrieved October 12, 2007, from EBSCO Host socINDEXwith full text-publications.

Davis, A. (1998). *The limits of educational assessment.* Oxford:Blackwell.

Department of Education (DoE). (1994). *Draft white paper on education and training. Government Gazette.* 351 (15974), 23rd September. Pretoria, South Africa: Government Printer.

Department of Education (DoE). (1995a). *White paper on education and training.* Notice 196. Pretoria, South Africa: Government Printer.

Department of Education (DoE). (1995b). *Syllabus for physical science (Higher Grade and Standard Grade).* Durban, South Africa: Government Printer.

Department of Education (DoE). (1997). *Draft statement on the national curriculum for Grades 1-9: discussion document. Government Gazette.* 18051. Pretoria, South Africa: Government Printer.

Department of Education (DoE). (1998a). *Draft assessment policy in the General Education and Training Phase Grades R to 9 and ABET. Government Gazette.* 396 (18998), 24th June. Pretoria, South Africa: Government Printer.

Department of Education (DoE). (1998b). *Lifelong learning for the 21st Century.* Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2000). *The General Education and Training Certificate (GETC). Government Gazette.* 426 (21888), 14th December. Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2001a). *White Paper 6.* Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2001b). *South African Qualifications Authority (SAQA).* Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2002a). *Learning area requirements for General Education and Training Certificate (GETC) Continuous Assessment (CASS): Natural Sciences.* Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2002b). A draft framework for the development of Common Tasks for Assessment: (CTA). Unpublished. Pretoria, South Africa.

Department of Education (DoE). (2002c). *Revised National Curriculum Statement Grades R-9. Natural Sciences.* Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2003a). *An interim policy framework for the assessment and promotion of learners in Grade 9.* 461(25699), 7 November. Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2003b). *Revised National Curriculum Statement Grades R-9 (RNCS). Teacher's guide for the development learning programmes. Natural Sciences.* Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2003c). *Declaration of the framework for the assessment and promotion of learners in Grade 9 as interim policy in terms of section 3(4)(L) of the National Education Policy Act, 1996 (Act no. 27 of 1996) and the South African Schools Act, 1996 (Act no.84 of 1996). Government Gazette*. 25699. Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2004a). *National Curriculum Statement Grades 10-12. Physical Sciences.* Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2004b). *Natural Sciences. Common Tasks for Assessment (CTA). Grade 9. Learner's Book. Section B.* Pretoria, South Africa: Government Printer.

Department of Education (DoE). (2004c). *Research study on curriculum and assessment in the General Education and Training Band – Grade 9.* Volume 5: Overview Document. Pretoria, South Africa: Government Printer.

Department of Education and Training: Government of Western Australia (2000). Focusing on outcomes: assessment-standardised tests. Retrieved November 11, 2005, from http://www.eddept.wa.edu.au/curriculum/focus/fc428.htm

Donnelly, J.K. (1987). Fifteen-year-old pupils' variable handling performance in the context of scientific investigations. *Research in Science and Technology Education, 5*, 135-147.

Driver, R., Squires, A., Rushworth, P. & Wood-Robinson, V. (1995). *Making sense of secondary science: research into children's ideas.* London: Routledge.

Duchastel, P.C. (1983). Text illustrations. *Performance and Instruction Journal, 22,* 3-5.

Duit, R. & von Rhöneck, C. (1998). Learning and understanding key concepts of electricity. In A.Tiberghien, E.J. Jossem & J.Barajos (Eds.), *Connecting research in physics education with teacher education,* Retrieved August 10, 2005, from http://www.physics.ohio-state.edu/~jossem/ICPE/C2.html

Dupin, J.J. & Joshua, S. (1989). Analogics and "modelling analogics" in teaching: some examples in basic electricity. *Science Education*, *73,* 207-224.

Duschl, R. & Gitomer, D. (1997). Strategies and challenges to changing the focus of assessment and instruction in science classrooms. *Educational Assessment, 4,* 37-73.

Ebel, R.L. (1972). *Essentials of educational measurement.* New Jersey: Prentice Hall.

Elwood, J. & Comber, C. (1996). *Gender differences in examinations at 18+: Final report.* London: University of London Institute for Education.

Evans, J. (1978). Teaching electricity with batteries and bulbs. *The Physics Teacher, 16,* 5-22.

Ferguson, E.S. (1977). The mind's eye: nonverbal thought in technology. *Science, 197,* 827-836.

Fensham, P.J. (1992). Science and technology. In P.W. Jackson (Ed.), *Handbook of research on curriculum* (pp. 789-829). New York: Macmillan.

Ferry, B., Hedberg, J. & Harper, B. (2002). Developing computer-based cognitive tools that assist learners to interpret graphs and tables. Retrieved June 13, 2005, from http://www.aare.edu.au/99pap/fer99092.html

Fiske, E.B. & Ladd, H.F. (2004). Balancing public and private resources for basic education: school fees in post-apartheid South Africa. In L. Chisholm, (Ed.), *Changing class: Education and social change in post-apartheid South Africa* (pp. 57-88). Pretoria, South Africa: Human Sciences Research Council (HSRC) Press.

Fredette, N. & Lockhead, J. (1980). Students' conceptions of simple circuits. *The Physics Teacher*, *18*, 194-198.

Gabel, D.L., Samuel, K.V. & Huhn, D. (1987). Understanding the particulate nature of matter. *Journal of Chemical Education, 64,* 695-697.

Gabel, D.L. (1993). Use of the particle nature of matter in developing conceptual understanding. *Journal of Chemical Education, 70,* 93-194.

Gabel, D.L. (1998). The complexity of chemistry and implications for teaching. In B. J.Fraser & K.G.Tobin (Eds.), *International handbook of science education* (pp. 821-842). Doordrecht, The Netherlands: Kluwer Academic Publishers.

Gipps, C. & Stobart, C. (1997*). Assessment: A teacher's guide to the issues*. London: Hodder & Stoughton.

Gilbert, J. (2002). Science and its 'other': looking underneath 'woman' and 'science' for new directions in research on gender and science education. *Gender and Education, 13*, 291-305.

Gobert, J. & Clement, J. (1999). Effects of student-generated diagrams versus student-generated summaries on conceptual understanding at causal and dynamic knowledge in plate tectonics. *Journal of Research in Science Teaching*, *36*, 39-53.

Green, W. & Naidoo, D. (2006). Knowledge contents reflected in post-apartheid South African Physical Science curriculum documents. *African Journal of Research in Science Mathematics and Technology (SMT) Education*, *10,* 71-80.

Harrison, C. (1980). *Readability in the classroom*. University of Nottingham School of Education: Cambridge University Press.

Hegarty, M., Carpenter, P. & Just, M. A. (1991). Diagrams in the comprehension of scientific texts. In R. Bar, M.L. Kamil, P.B. Mosenthal & P.D. Pearson, (Eds.), *Handbook of reading research* (pp. 641-667). White Plains, N.Y.: Longman Publishing Company.

Hendricks, A. (1999). Electricity. In M.B. Ogunniyi, (Ed.), *Assessment of Grades 7-9 pupils' and knowledge and interest in science and technology* (pp. 180-205). Bellville, South Africa: University of Western Cape (UWC).

Howie S.J. (2001). *Mathematics and science performance in grade 8 in South Africa 1998/1999. TIMSS-R 1999*. Pretoria: Human Sciences Research Council (HSRC).

Human Sciences Research Council ((HSRC). 2005). *Grade 6 systemic evaluation: Western Cape Province*. Pretoria, South Africa: Human Sciences Research Council (HSRC).

Inal, A. (2002). *Practical science process skills in physics with special reference to test item assessment and classification*. Unpublished MEd dissertation. Rondebosch, South Africa: University of Cape Town.

Jaakkola, T. & Nurmi, S. 2004. *Academic impact of learning objects: the case of electric circuits*. Paper presented as part of the 'Learning objects in the classroom: a European perspective' symposium at the British Educational Research Association annual conference, Manchester. Retrieved August 10, 2006, from Education Resources Information Centre (ERIC).

Jansen, J.D. (2001). Explaining change and non-change in education after apartheid. In Y.Sayed & J. Jansen (Eds.), *Implementing education policies: The South African experience* (pp. 271-293). Cape Town: University of Cape Town Press.

Janvier, C. (1978). *The interpretation of complex cartesian graphs representing situations: studies and teaching experiments*. Unpublished PhD Thesis. University of Nottingham.

Johnstone, A.H. (1993). The development of chemistry teaching. *Journal of Chemical Education, 70*, 701-705.

Kanjee, A. (2006). Comparing and standardising performance trends in the matric examinations using a matrix sampling design. In V.Reddy (Ed.), *Marking matric: Colloquium proceedings* (pp. 72-89). Cape Town: Human Sciences Research Council (HSRC).

Keegan, L. Superintendent of Public Instruction, State of Arizona. Retrieved August 12, 2006, from http://www.illinoislooporg/quotes.html-275k

Kerlinger, F.N. (1986). *Foundations of behavioural research*. New York: Holt, Rinehart & Winston.

Khanyane, M.M. (2002). *The interpretation of biology textbook illustrations by Grade 10 learners.* Unpublished MEd research report. University of the Witwatersrand, Johannesburg, South Africa.

Koch, A. (1995). Skills needed for reading comprehension of physics texts and their relation to problem-solving ability. *Journal of Research in Science Teaching, 32,* 613-628.

Kozma, R.B. & Russel, J. (1997). Multimedia and understanding: expert and novice responses to different representations of chemical phenomena. *Journal of Research in Science Teaching, 34*, 949-968.

Laugksch, R.C., Muller, J., Abel, L., Soudien, C. & Favish, J. (2005). *Contexual, institutional, classroom and systemic level factors that impact on the success of black learners in high school mathematics and science.* Unpublished report prepared for the Mathematics and Science Education Project (MSEP) Board. Rondebosch, South Africa: University of Cape Town.

Leinhardt, G., Zaslavski, O. & Stein, M.K. (1990). Functions, graphs and graphing: tasks, learning and teaching. *Review of Educational Research, 60,* 1-64.

Levinson, R. (1994). *Teaching science.* London: Routledge.

Malcolm, C. (2001). Implementation of outcomes-bases approaches to education in Australia and South Africa: a comparative study. In Y. Sayed & J. Jansen (Eds.), *Implementing education policies: The South African experience* (pp. 174-188). Cape Town, South Africa: University of Cape Town Press.

Malcolm,C., Keane, M., Hoohlo, L., Kgaka, M. & Ovens, J. (2001). *Why some "disadvantaged" schools succeed in mathematics not science: a study of "feeder" schools.* Pretoria, South Africa: Department of Education.

Mammino, L. (2002). Imagery: a tool for the generation, expression and recognition of students' views about the world of molecules. In C. Malcolm & C. Lubisi (Eds.), *Proceedings of the 10th Annual Conference of the South African Association for Research in Mathematics, Science and Technology Education (SAARMSTE)* (pp. 237-242). Durban, South Africa: University of Natal.

Manganyi, N.C. (2001). Public policy and the transformation of education in South Africa. In Y.Sayed & J. Jansen, (Eds.), *Implementing education policies: The South African experience* (pp. 271-293). Cape Town, South Africa: University of Cape Town Press.

Mangxamba, S. (2006). *Grade 6 literacy shocker.* Cape Argus, 10th July, pp.1-2.

Mda, T. (2004). Multilingualism and education. In L. Chisholm, (Ed.), *Changing class: Education and social change on post-apartheid South Africa* (pp. 57-88). Pretoria, South Africa: Human Sciences Research Council (HSRC) Press.

Mehrens, W.A. (1989). Preparing students to take standardised achievement tests. *Practical Assessment, Research and Evaluation*, 1(11). Retrieved November 7, 2005, from http://pareonline.net/getvn.asp?v=1andn=11.

Moodie, P. (1990). *Science Education Project: Physical Science, std. 6.* Pretoria, South Africa: Science Education Project.

Moja, T. & Hayward, F. (2001). Higher education policy development in contemporary South Africa? In Y. Sayed & J. Jansen (Eds.), *Implementing education policies: the South African experience* (pp.112-123). Cape Town, South Africa: University of Cape Town Press.

Muller, J. (2004). Assessment, qualifications and the NQF in South African schooling. In L. Chisholm, (Ed.), *Changing class: Education and social change on post-apartheid South Africa* (pp. 57-88). Pretoria, South Africa: Human Sciences Research Council (HSRC) Press.

Nkopodi, N. & Rutherford, M. (1994). Some data collection methods used to identify conceptual and language difficulties. In M.J.G Lencross (Ed.), *Proceedings of the 2nd Annual Meeting of the Southern African Association for Research in Mathematics and Science Education (SAARMSTE)* (pp. 300-313). Durban, South Africa: University of Natal.

Nurrenbem, S.C. & Pickering, M. (1987). Concept learning versus problem solving: Is there a difference? *Journal of Chemical Education, 64*, 508-510.

Ogunniyi, M.B. (1999). Assessment of grades 7-9 pupil's knowledge and interest in science and technology – STL (Science and Technology Literacy) Project. School of Science and Mathematics Education (SSME): University of Western Cape.

Organisation for Economic Co-operation and Development (OECD) (2001). *Knowledge and skills for life: first results from PISA 2000.* Paris: Organization for economic co-operation and development (OECD).

Palincsar, A.S. (1998). Social constructivist perspectives on teaching and learning. Retrieved February 10, 2008, from http://www.coe.ohio-state.edu/ahoy/Palincsar.pdf.

Perry, H. & Fleisch, B. (2006). Gender and educational achievement in South Africa. In V.J.Reddy, (Ed.), *Marking matric: Colloquim proceedings* (pp. 107-126). Cape Town, South Africa: Human Sciences Research Council (HSRC) Press.

Pfundt, H. & Duit, R. (1994). *Bibliography. Students' alternative frameworks and science education.* Kiel, Germany: Institut für die Pedagogik der Naturwissenschaften (IPN).

Phurutse, M.C. (2006). Listening to matric teachers: township realities and learner achievement levels. In V. J. Reddy (Ed.), *Marking matric: Colloquium proceedings* (pp. 213-227). Cape Town, South Africa: Human Sciences Research Council (HSRC) Press.

Porter, A. & Smithson, J. (2001). Are content standards being implemented in the classroom? A methodology and some tentative answers. In S. Fuhrman (Ed.), *From capitol to the classroom: standards-based reform in the states* (pp. 60-80). University of Chicago, IL: National Society for the Study of Education.

Preece, J. (1985). *Interpreting trends in graphs: A study of 14 and 15 year olds.* Unpublished PhD thesis. University of Nottingham.

Psillos, D. Koumaras, P. & Tiberghien, A. (1988). Voltage presented as a primary concept in an introductory teaching sequence on DC circuits. *Journal of Science Education, 10,* 29-43.

Pudlowski, Z.J. (1988). Visual communication via drawings and diagrams. *International Journal of Applied Engineering Education*, *4*, 301-315.

Rademeyer, J. (2006). *The bottom of the class.* Sunday Times, 1 January, p.10.

Reddy,V. (2006a). *Mathematics and science achievement at South African schools in TIMSS 2003.* Cape Town, South Africa: Human Sciences Research Council (HSRC) Press.

Reddy, V. (2006b). The state of mathematics and science education: schools are not equal. In S.Buhlungu, J. Daniel, R. Southall & J. Lutchman (Eds.), *State of the Nation: South Africa 2005-2006* (pp. 392-416). Cape Town, South Africa: Human Sciences Research Council (HSRC).

Reddy, V., van der Berg, S., Lebani, L & Berkowitz, R. (2006). A trend analysis of matric maths performance. In V.Reddy (Ed.), *Marking Matric* (pp. 139-158). Cape Town, South Africa: Human Sciences Research Council (HSRC) Press.

Reeves, C.A. (2005). *The effect of opportunity to learn and classroom pedagogy on mathematics achievement in schools serving low socio-economic status communities in the Cape Peninsula.* Unpublished PhD thesis, University of Cape Town.

Riddel, A.R. & Nyagura, L.M. (1991). What causes differences in achievement in Zimbabwe's secondary schools? Population and Human Resources Department. The World Bank. June. WPS 705. Retrieved August, 13, 2005, from http://www.worldbank.org/

Rillero, P. (1998). Process skills and content knowledge. *Science Activities, 35,* 3-4.

Rochford, K. & de Jager, G. (1990). Relationships between student performance on the electrical engineering aptitude test and achievement in electrical and electronic engineering courses at the University of Cape Town. In Z.J. Pudlowski (Ed.), *An aptitude test and associated research in basic electrical circuits* (pp. 23-30). The Electrical Engineering Education Research Group. Sydney: University of Sydney.

Rochford, K., Fairall, A.P., Irving, A. & Hurly, P. (1989). Academic failure and spatial visualization handicap of undergraduate engineering students. *International Journal of Applied Engineering Education, 5*, 741-749.

Rogan, J.M. (2000). Strawberries, cream and the implementation of Curriculum 2005: Towards a research agenda. *South African Journal of Education, 20,* 118-125.

Rothman, S. (1997). *Factors influencing assigned student achievement levels.* South Australian Department of Education and Training. Retrieved March 22, 2006, from http://www.aarc.edu.au/98pap/rot98337.htm

Roth, W. & McGinn, M.K. (1997). Graphing: Cognitive ability or practice? *Science Education, 81,* 91-106.

Sadeck, M. (1999). Energy and change. In M.B.Ogunniyi (Ed.), *Assesment of grades 7-9 pupils' knowledge and interest in science and technology* (pp. 166-171). Bellville, South Africa: School of Science and Mathematics Education (SSME) Press.

Sadeck, M. (2003*). Peninsula technicon first year preservice teachers' conceptions of heat and temperature.* Unpublished MEd thesis, University of the Western Cape.

Sadeck, M. & Scholtz, Z. (2003). A process skills profile of pre-service science teachers at Peninsula Technikon. In B.Putsoa., M. Dlamini, B. Dlamini & V. Kelly, (Eds.). *Proceedings of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE)* (pp. 749-754). Waterford, Swaziland: Webster Print.

Sayed, Y. (2002). Educational policy in South Africa: from opposition to governing and implementation. *International Journal of Educational Development, 22,* 29-33.

Schofield, B. (1989). *Science at age 13: a review of assessment of performance unit (APU) survey findings 1980-1984.* London: Her Majesty's Stationary Office.

Sencar, S. & Eryilmaz, A. (2003). Factors mediating the effect of gender on ninth-grade Turkish students' misconceptions concerning electric circuits. *Journal of Research in Science Education, 41,* 603-616.

Shepard, R.N. (1978). Externalization of mental images and the act of creation. In B.S. Randhava and W.E. Coffman (Eds.), *Visual learning, thinking and communication* (pp. 98-121). New York, NY: Academic Press.

Shepard, L.A. (2000). The role of assessment in a learning culture. *Educational Researcher*, *29*, 4-14. Retrieved July 4, 2006, from http://www.jstor.org//sici?

Shepard, L.A. (2001). The role of assessment in teaching and learning. In V.Richradson, (Ed.), *Handbook of research on teaching* (pp. 1066-1101). Washington, DC: American Educational Research Association.

Shepard, L.A. (2003). Reconsidering large-scale assessnt to heighten its relevance to learning. Retrieved September 20, 2008, from http://www.nsta.org/permissions.

Shipstone, D.M. (1985a). Electricity in simple circuits. In R. Driver, E. Guesene & A. Tiberghien, (Eds.), *Children's ideas in science* (pp. 33-51). Milton Keynes, UK: Open University Press.

Shipstone, D.M. (1985b). A study of children's understanding of electricity in simple DC circuits. *Journal of Science Education*, *6*, 185-198.

Siebörger, R. (2004). *Transforming assessment: a guide for South African teachers.* Cape Town, South Africa: Juta.

Singh, S.K. (2008). Assessment in Natural Sciences: A rural case study. In M. V. Polaki, T. Mokuku & T. Nyabanyaba (Eds.), *Proceedings of the 16th Annual Conference of the South African Association for Research in Mathematics, Science and Technology Education (SAARMSTE).* Maseru, Lesotho: University of Lesotho.

Smith, I.M. (1964). *Spatial ability: its educational and social significance.* London: University of London Press.

Spady, W.G. (1994). *Outcomes-based education: critical issues and answers.* Arlington, USA: American Association of School Administrators (AASA).

Stanton, M. (1990). Student's alternative conceptions of the DC circuit – 3. *Spectrum, 28*, 32-38.

Taber, K.S. (2006). Beyond constructivism: the progressive research programme into learning science. *Studies in Science Education, 42*, 125-184.

Tell, C. (1998). Whose curriculum? A conversation with Nicholas Tate. *Educational Leadership*, *56*, 64-69.

Trochim, W.M.K. (2001). *The research methods knowledge base*. United States of America: Cornell University.

Vandeyar, S. & Killen, R. Has curriculum reform in South Africa really changed assessment practices, and what promise does the revised National Curriculum Statement hold? *Perspectives in Education, 21,* 119-134. Retrieved June 20, 2007, from South African Publications.

van Zyl, E.J., Lerm, E.R., van Wyk, J.P. & van Rensburg, N.P.J (2001). *Study and Master: General Science. Grade 9.* Somerset West: Roedurico Trust.

Verhage, H. & De Lange, J. (1997). Mathematics education and assessment. *Pythagoras, 42*, 14-20.

Verma, G. & Mallick, P. (1999). *Researching education: perspectives and techniques.* London: Falmer Press.

von Glasersfeld, E. (1995). A constructivist approach to teaching. In Steffe, L.P. & Gale, J. (Eds.), *Constructivism in education* (pp. 3-15). New Jersey: Lawrence Erlbaum Associates.

Vulliamy, G., Lewin, K. & Stevens, D. (1990). *Doing educational research in developing countries.* London: Falmer Press.

Vygotsky, L.S. (1978). *Mind in society. The development of higher psychological processes.* Cambridge, MA: Havard University Press.

Wellington, J. (1989). *Skills and processes in science education: a critical analysis.* London: Routledge.

Weaver, C. (1996). Facts. On standardised tests and assessment alternatives. Retrieved November 7, 2005, from http://homepage.tinet.i.e/~seaghan/articles/10.htm

Welton, J. (2001). Building capacity to deliver education in South Africa? In Y. Sayed & J. Jansen (Eds.), *Implementing education policies: the South African experience* (pp. 174-188). Cape Town, South Africa: University of Cape Town Press.

Wertsch, J.V. (1997). *Vygotsky and the formation of the mind.* Cambridge, MA: Harvard University Press.

Western Australia. Department of education and training. (2000). Focusing On Outcomes. Retrieved November 11, 2005, from http://www.eddept.wa.edu.au/curriculum/focus/fc428.htm

Western Cape Education Department. (WCED). April (2005). *Natural Sciences Learning Area. GET: Senior Phase Grades 7-9.* Resource Material. Cape Town, South Africa.

White, L. (2003). Process skills: are teachers equipped and ready to implement? In B.Putsoa., M. Dlamini, B. Dlamini & V. Kelly (Eds.), *Proceedings of the South African Association for Research in Mathematics, Science and Technology Education* (pp. 763-769). Waterford, Swaziland: Webster Print.

Whitford, B.L. & Jones, K. (2000). Kentucky lesson: How high stakes school accountability undermines a performance-based curriculum vision. In B.L.Whitford & K.Jones (Eds.), *Accountability, assessment and teacher commitment: lessons from Kentucky's reform efforts* (pp. 210-234). Albany, NY: State University of New York Press.

Wiggins, G. (1993). *Assessing student performance: Exploring the purpose and limits of testing.* California: Jossey-Bass.

Wilmot, D. (2003). On phase of a case study of outcomes-based education assessment policy in the Human and Social Sciences Learning Area of C2005. *South African Journal of Education, 23*, 313-319.

Wilmot, D. (2004). *Making OBE work in Human and Social Sciences at two Eastern Cape schools: navigating Curriculum 2005 policy, advancing curriculum innovation and implementing the 2003 Grade 9 CASS and CTA.* Unpublished manuscript. Rhodes University. Grahamstown, South Africa.

Winn, B. (1987). Charts, graphs and diagrams in educational materials. In D. M. Willows & H. A. Houghton (Eds.). *The Psychology of illustration volume 1: basic research* (pp. 152-198). New York, NY: Springer-Verlag.

Woodward, C. & Woodward, N. (1998). Girls and science: does a core curriculum in primary school give cause for optimism? *Gender and Education, 10*, 387-400.

World Bank (2001). The nature of public examinations. Retrieved October 4, 2005, from http://www1.worldbank.org/education/exams/nature. asp

Wu, H.K., Krajcick, J.S. & Soloway, E. (2001). Promoting understanding of chemical representations: students' use of a visualization tool in the classroom. *Journal of Research in Science Teaching, 38*, 821-842.

APPENDICES

APPENDIX 1

COPIES OF THE NATURAL SCIENCE COMMON TASKS FOR ASSESSMENT (CTA) GRADE 9 : 2004 SECTION A, SECTION B AND SECTION B MEMORANDUM

DEPARTMENT OF EDUCATION

TIRISANO
WORKING TOGETHER

DEPARTMENT OF EDUCATION

NATURAL SCIENCES
(NS)

Common Tasks for Assessment (CTA)
Grade 9
2004

LEARNER'S BOOK

SECTION A

Time: 5 hrs

Marks: 120

No. of Pages: 24

THE COMMON TASKS FOR ASSESSMENT (CTA)

PROGRAMME ORGANISER: Sustainable living

FOCUS: Understanding the importance and functions of water.

Note to the learner:

This CTA consists of a Section A and a Section B. This is section A.

Section A:

- This section must be completed within 5 hours, which may be spread over a number of days.
- Answer Section A in your own exercise book or in the way you and your teacher agree upon.
- You will do some of the activities as an individual and others as a member of a group or pai You may consult or ask for help. In the end, you must be able to justify all your answers.
- It is important to show all your calculations because then your teacher will be able to see hc you have reasoned and which skills and knowledge you have applied.
- Section A also prepares you to answer Section B. Therefore, ensure that you have mastere the knowledge and skills you applied in Section A so that you can attempt and complete Section B successfully.

Section B:

- You will have 2 hours to complete this section.
- You will complete Section B on your own.
- You may use a calculator where necessary.

Icons used:

TASK 1

This indicates that a new task has begun.

Activity 1

This indicates that a new activity of your task has begun.

CONTENTS

Introduction

The CTA consists of two components: Section A and Section B.

- Section A is a preparatory component, and is made up of three tasks. The time and mark allocation is indicated for all activities. Section A is given 120 marks. Complete all the activities for Section A, as these will prepare you for answering the questions in Section B.
- Section B is an activity that you complete individually under controlled conditions. There are five questions, which test the application of what you learnt in Section A. You will not be allowed to take Section A into the room in which you write Section B

The task in Section A requires that you prepare a presentation for a public meeting.

- In order to prepare your presentation, and prepare your argument, you will have to go through a number of preparatory activities in which you

  carry out an investigation,
  gather data,
  do calculations,
  answer questions, and
  learn concepts.
- Certain people propose to build a dam near Gariepville which will cover a *wetland area near an urban area. You must prepare a presentation in writing that you can present at the public meeting. You need to comment on the scientific aspects of the claims and counter claims different interest groups are making about the issues. Your presentation needs to make the case for a particular course of action.
- You must pretend to be one of the #stakeholders in Gariepville, a small town with the wetland which is under threat. Read more about Gariepville later. The data and information you get from doing the activities will help you to prepare a good, interesting and scientifically-informed presentation.

  * wetland - a place where land is regularly under water for long periods during a year.

  # stakeholder - a person who is a member of one of the groups directly affected by any decisions

SECTION A: Details of Assessment Tasks

Page Number	Activity	SOs	Description of the task	Form of assessment / Product	Who Assesses?	Marks	Time
8	1.1. expanded opportunity	2	Demonstrate knowledge and understanding of formulae Application of formulae Estimations and making assumptions	Calculations and application	Peer Educator	25 not recorded	[30 min] expanded opportunity
9	1.2	1, 2, 3	Formulate the hypothesis, describe the test and investigate, predict the result Estimate calculation	Correct prediction, hypothesis, testing, estimating	Educator Peer	15	30 min
10	1.3	1, 2, 2	Conduct experiment / Demonstrate Communicate results / State conclusion Scientific knowledge, concepts and principles used.	Demonstration Present diagrams	Educator	15	60 min
12	2.1	2	Represent chemical substances using chemical symbol and sketches	Chemical diagram	Educator	10	15 min
13	2.2	2	Represent chemical substances using symbol and chemical equation	Balanced chemical equations	Educator	15	30 min
15/16	2.3 and 2.4	2	Interpretation of the graph	Complete table Translation Activity		8 + 7	homework 10min 30 min
16	2.5		Expanded opportunity Brainstorm advantages and disadvantages of hydro-electric power	Make a list	Self / peer	-	[20 min] expanded opportunity
20	3.1	2	Identifying concept on wetlands	Concept map	Educator Peer	10 - Not recorded	20 min
21	3.2	2, 3, 4	Showing links between wetlands and cultural issues	Poster or radio advert	Educator	7	15 min
22	3.3	1, 2, 4, 6, 7, 8	Formulate and investigation Identify the variables Investigate efficacy of medicinal plant	Investigation	Educator	8	30 min
23	3.4	2, 5	Classification of plants and animals Adaptations to habitat Food relations	Understanding of concepts	Educator	15	30 min
24	4	1, 2, 5, 6, 9	Preparing for final presentation COMPLETE FINAL PRESENTATION AT HOME	Written presentation Making notes	Educator	20	30 min

[120] marks

Let's get started

Read the following introduction on Gariepville and then complete the activities. Do them well and have fun!

(Remember: these activities also prepare you for doing well in Section B)

TASK 1 To build a dam or not

Time: 40 min

Marks: 84

A strong flowing river falls over a waterfall into a wide deep valley. There is a small village in the valley where a group of people have lived and buried their ancestors for hundreds of years. The wetland that covers the floor of the valley supports a wide diversity of plants and animals. The local community also exploits the riches the wetland provides. The small town of Gariepville, with a population of about 2000 people, is situated on the banks of the river, a few kilometres down river from the valley. Still further down the river farmers irrigate their land using river water. They grow fruit. The farmers provide employment to hundreds of people from the local community that lives in and around the town. An international mining company has found a large valuable mineral deposit nearby. The company is proposing to the government that the government dams the river by building a wall at the bottom of the valley. The government wants to use the water to generate electricity. The mining company wants to use the water in the mining process.

You and your group of friends attend school in the town. You are aware of the tension and confusion that this issue is causing amongst the people.

The government with its ongoing policy of consultation has agreed to a meeting in the town hall at which the various interested parties can argue for or against the proposal to build the dam. The following are the representatives of the interested parties.

Stakeholders

- Maria van Jaarsveldt, head of Fruit Farmers Association
- Andries Koopman, head of the Fruit Farm Workers' Union
- Mr Thomas Harrison, the manager of the international mining company
- Johannes Kok, the community leader of 'the valley people' who lives where it is proposed that the dam should be built
- You, yourself, a learner from the local high school in the town, elected to represent your fellow learners, being a future adult of Gariepville.

Activities

You will work in groups of 4 or 5 learners for most activities. However, you will often have to submit your own written work at the end of the group activity. For the last activity each member of the group must select to pretend to be one of the persons from the list of interested parties. Your teacher may give members of the same interest groups (expert groups) time to get together to help develop their presentations.

Activity 1: Lighting up

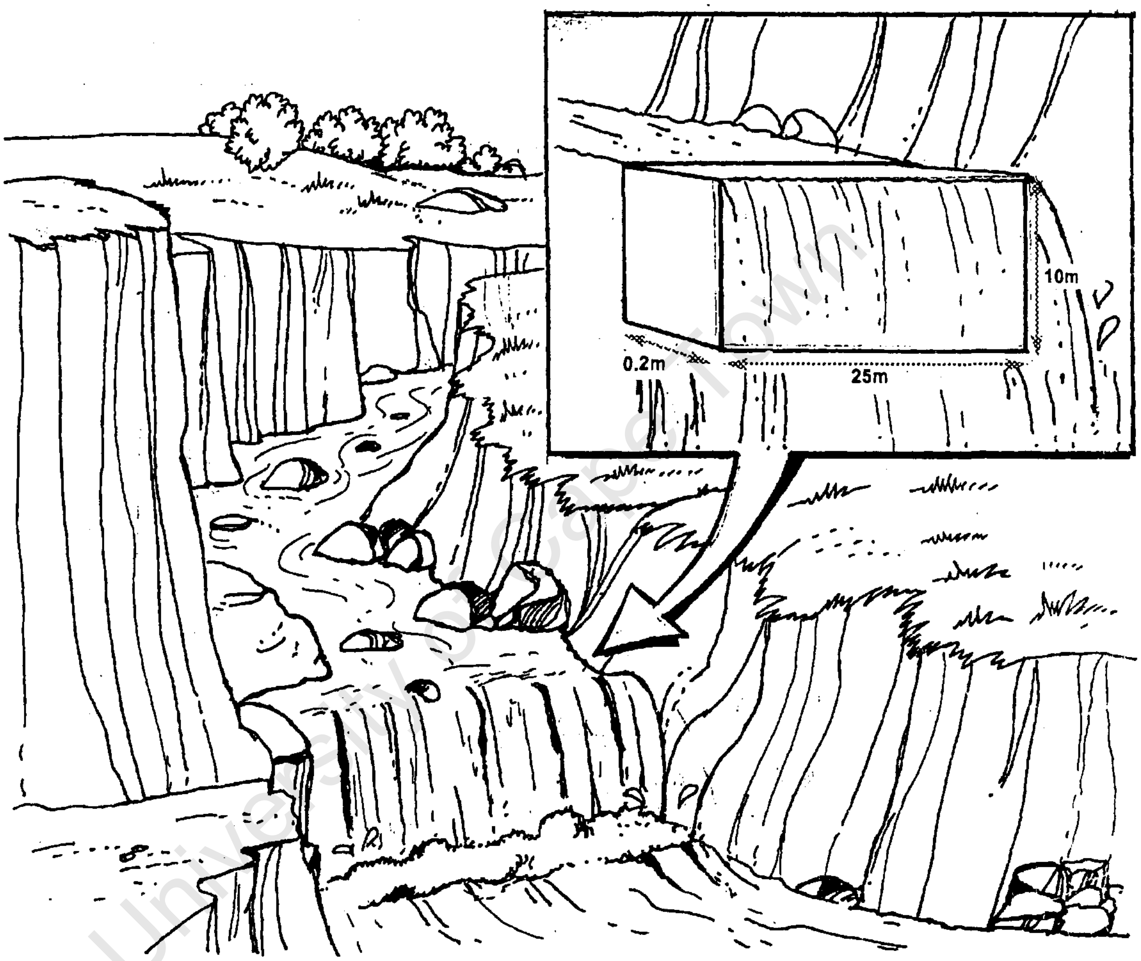
Time: 90 min

Marks: 30

We can generate electricity using the water we store in dams. This is because this water has energy because of its height above the bottom of the dam (potential energy). Instead of letting all the water run over the dam wall ,we let some run down large pipes. The water speeds up, changing its potential energy into kinetic energy (energy of motion). This drives generators and transfers the kinetic energy of the water into electricity that can do work like run motors or provide heat.

We can use the information we provide in Activity 1.1 to estimate that this dam can generate 15 MW of electric power. In Activity 1.1, which is an optional expanded opportunity, learners can carry out this estimation.

Activity 1.1 EXPANDED OPPORTUNITY (marks not recorded*) Calculating electric power



The river is 25 m wide with an average depth of 10 m with a flow rate of 0.2 m/s where the river flows over the waterfall. The height of the wall of the proposed dam is greater than 30 m.

a) Answer the following questions
   1 What is the mass of a litre of water?
   2 How many litres in a cubic meter?
   3 What is the weight of 1 kilogram of water?
   4 How much work must we do to lift a kilogram of water 30 m?
   5 How much energy can be transferred to an electric generator by a litre of water falling 30 m?

b) Use this information to estimate the electrical power that can be generated using this dam.

c) Give any assumptions you make and show how you calculated your answer.

(25)*

Table 1

Bulb	My prediction Lights up? YES / NO	Bulb Bulb	My prediction Lights up? YES / NO	Bulb	My prediction Lights up? YES / NO
A		F		K	
B		G		L	
C		H		M	
D		I		N(1)	
E		J		N(2)	

b) Write a hypothesis that gives the general rule that you have used to decide which light bulbs light up. You should be able to test your rule with an experiment. (6)

c) Describe how you can test your rule. (You can use a labelled sketch and a circuit diagram together with a written explanation that refers to your diagram.) (7)

d) We can now estimate the number of households the power from this hydro-electric scheme can supply if all the households draw their maximum power supply at the same time. We will assume each household is allowed to draw 30 A at 200 V.

Power for one household: P = IV = 30 A x 200 V = 6 000 W = 6 kW

Power from hydro-electric plant = 15 MW = 15 000 kW

$$\text{Number of households} = \frac{15\ 0000\ \text{kW}}{6\ 000\ \text{kW}} = 2\ 500$$

This is more than enough power to supply the small town of Gariepville.

Activity 1.3 Choosing connections for lighting a home

Time: 60 min

✓ Marks: 15

You are supplied with three 3.8 V torch bulbs, copper connecting wires and two 1.5 V torch cells.

Work in a group.

a) Each member of the group should produce their own report in which they:

- give a sketch to show how to make a torch bulb light up.
- represent their sketch using a circuit diagram.

Each member of the group should carry out their plan to test their rule for making a torch bulb light up.

- Demonstrate to your peers how to make a single torch bulb light up using this equipment and explain why your connection works. (5)
- Assess the other members of your group. Your teacher will give you the sketch and the circuit and help you with the allocation of marks.

Activity 1.2 Connecting in series and parallel
(Do this activity at home)

Time: 30 min

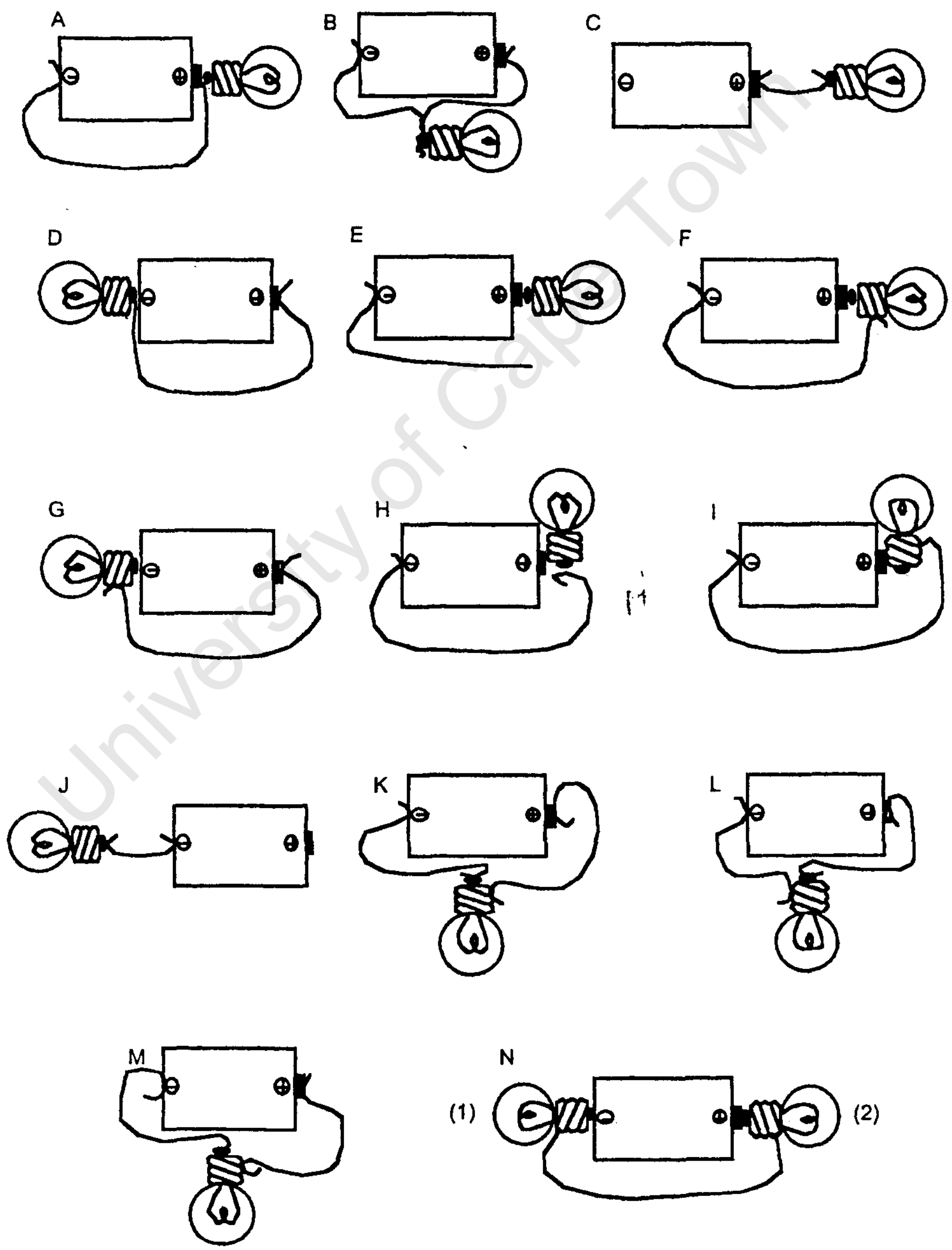
Marks: 15

In order to understand the extent to which this dam can contribute to the electrical needs of the country we will explore the electrical needs of Gariepville.

Look at the sketches of light bulbs, connectors and batteries labelled A to N(2) shown below.

a) Predict which of the following bulbs will light up. Work on your own at home. Give your prediction on Table 1 below the diagrams. Write down 'YES' or 'NO' to indicate which bulbs will light up.

Figure 1



Reference: Adapted from: M. Stanton, Student's alternative conceptions of the DC circuit – 3; Spectrum October 1990, Volume 28 Number 4, p32.

b) Each **group** demonstrates to their teacher the advantages and disadvantages of connecting bulbs in parallel and in series for the lighting system of a house.

Each group member provides his / her own

- Table of the results of the group demonstration. (5)
- States the group's decision as to the way to connect lights in a house.
- Draws a circuit diagram for the lights of a house with four rooms. (5)

c) EXPANDED OPPORTUNITY

Each group member provides his / her own calculations to show the effect of series and parallel connections on

- the current that flows through the battery
- the voltage of the battery required and
- the length of time a battery will last.

(For the purpose of these calculations work with 4 torch bulbs and assume they have a fixed hot temperature resistance of 10 ohms and operate correctly with a voltage of 4.5 V and a torch cell that can supply a charge of 4 Amp-hr.)

TASK 2 Activity 2: Burning up

Time: 85 min
Marks: 40

The community in the valley burns candles for light and uses wood to cook and for heating.

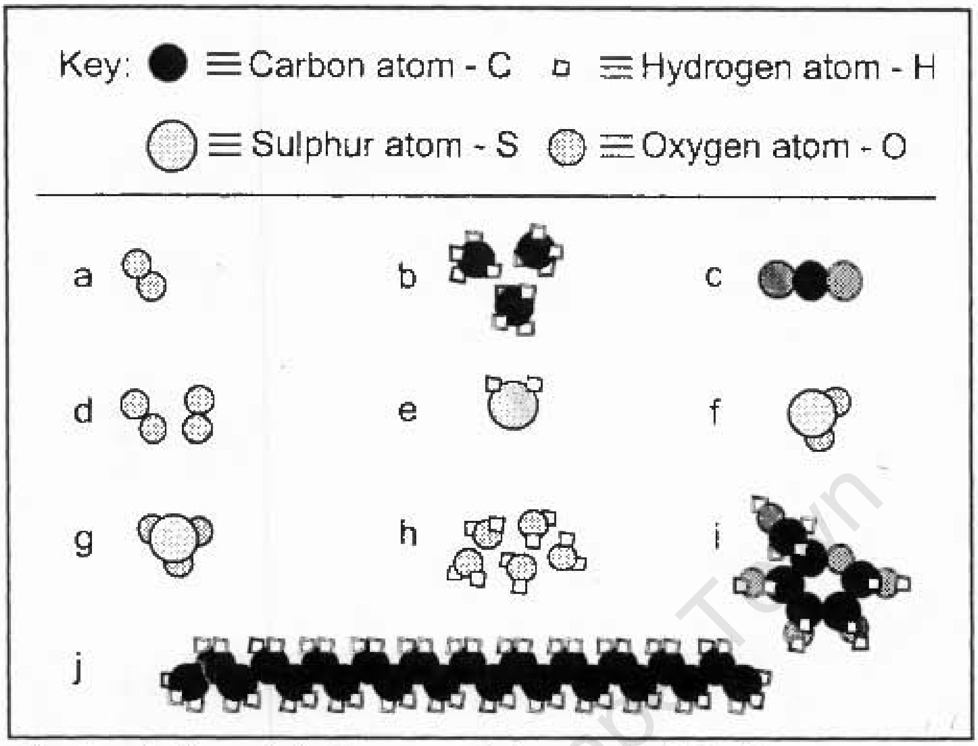
Oxygen in the air is needed to burn any substance. When we use candles the substance that burns is candle wax. We call candle wax and oxygen the **reactants**. The new substances that form during the reaction are carbon dioxide and water vapour. We call these substances the **products** of the reaction. There is a transfer of energy as light and heat during the reaction.

Activity 2.1 Representing chemical substances using chemical symbols and sketches

Time: 15 min
Marks: 10

We use symbols to represent the chemical formulae of molecules and compounds. For example, using the key in Table 2 below, the sketch labelled 'a', represents an oxygen molecule with the chemical formula 'O_2'; and the sketch labelled 'b' represents three molecules of methane with the chemical formula 'CH_4'. We write this as '$3CH_4$'.

Table 2



a) Give the chemical formula for the representations labelled 'g' to 'j' (c to f optional). (5)

b) Using the key in Table 2, represent the following chemical formulae using sketches similar to those above

a. H_2 b. CS_2 c. $3CO_2$ d. C_2H_5 (5)

Activity 2.2: Representing chemical reactions using symbols and chemical equations

Time: 30 min

✓ Marks: 15

Methane is like the gas we find in gas cylinders. We can burn methane to cook. Methane has the formula CH_4.

Methane burns to produce carbon dioxide and water.

We can represent this reaction in three different ways, using:

- a word equation:

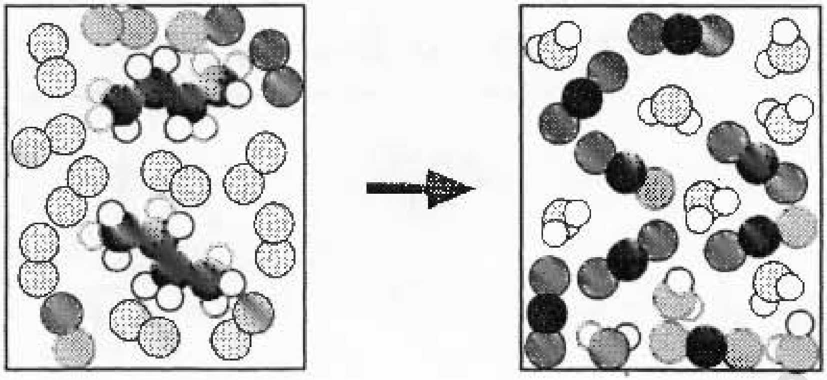
  Methane + oxygen → water + carbon dioxide

- sketches, using the same key as in Table 2:

- a balanced chemical equation: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

a) Butane (lighter fuel) also burns.

We can represent this reaction using sketches and the same key as in Table 2, as follows:



1 What is the formula for butane? (1)

2 Copy and complete Table 3 for this reaction.

Table 3 (5)

Reactants					Products				
Name of Substance	No. of atoms			No. of molecules	Name of Substance	No. of atoms			No. of molecules
	O	C	H			O	C	H	
TOTAL					TOTAL				

3 Use the copy of Table 3 you have completed to help you write a balanced equation for this reaction: (4)

b) Represent each of the following chemical reactions using

- words;
- sketches. (For sketches, use the KEY provided in Table 2); and
- a balanced chemical equation

1 Sulphur burns in oxygen to form sulphur dioxide.

2 Carbon burns in a limited supply of oxygen to form carbon monoxide. (Optional)

3 Propane (C_3H_8) burns in air to form carbon dioxide and water. (Optional) [5]

Activity 2.3: Burning wood for cooking and heating (Do this activity at home)

Time: 10 min

Marks: 8

The valley people do not have access to electricity. They meet most of their energy requirements by burning wood. This can be dangerous if the fire has an inadequate supply of oxygen as can happen if the fire is indoors. In these circumstances the fire produces the poisonous gas carbon monoxide which is often responsible for suffocating people during cold winter nights. People who burn wood may also cut down trees to obtain their fuel.

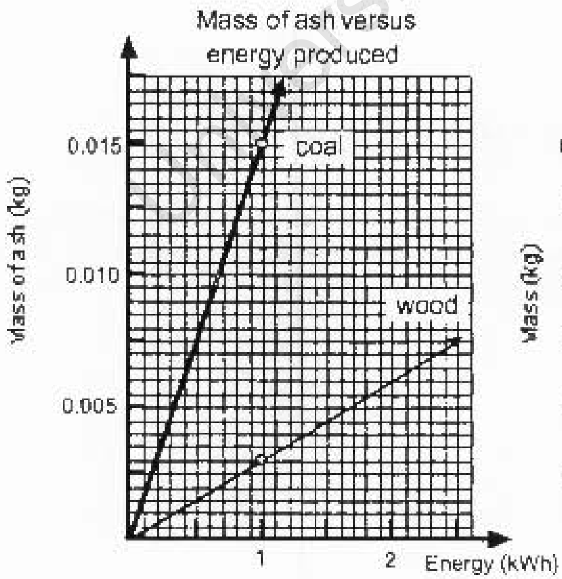
Coal is a major source of our energy in South Africa. We burn coal in oxygen rich furnaces to produce electricity in power stations that are mostly in Mpumalanga. The coal we burn contains up to 5% sulphur and 10% ash. Ash is the major part of what we call smoke. Both smoke and sulphur dioxide are very bad for our health.

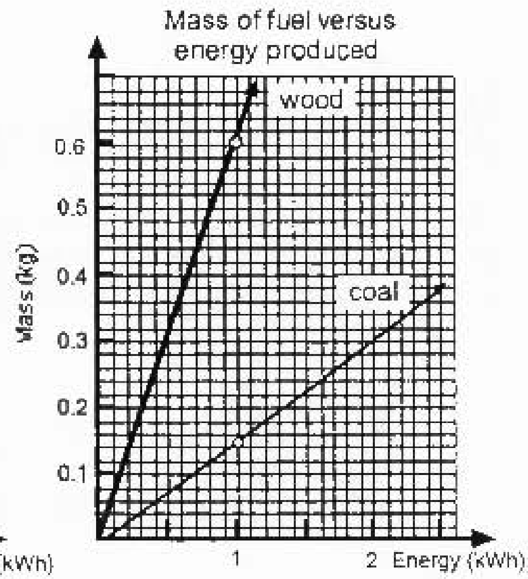
Use the four graphs below that give information about burning coal and wood, then copy and complete Table 4.

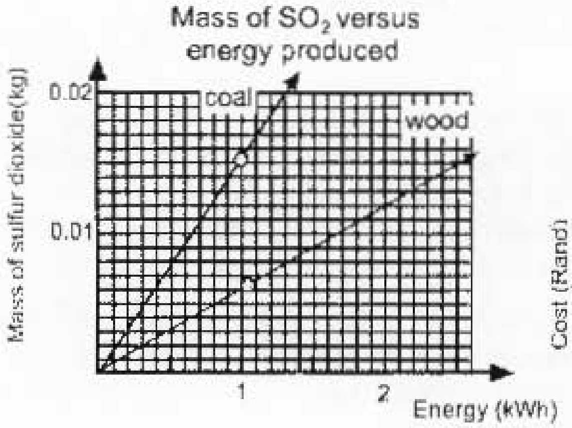
Table 4

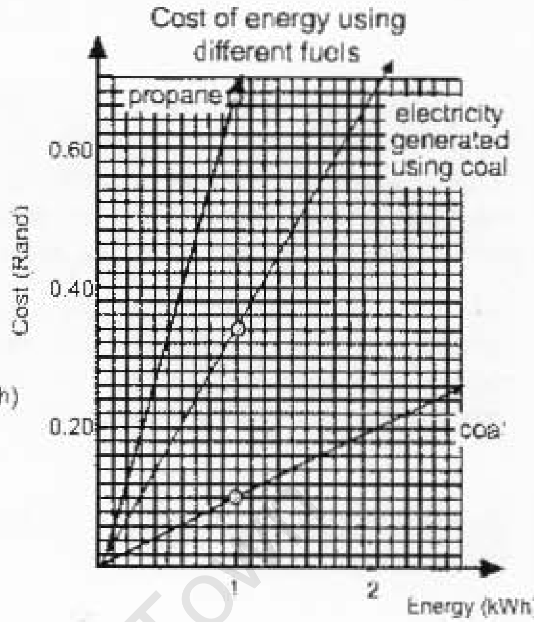
Fuel	Energy produced	Mass used (kg)	Mass of SO_2 produced (kg)	Mass of ash produced (kg)	Carbon monoxide produced
Coal in power station	1 kWh				Yes/no
Wood in open fire	1 kWh				Yes/no

(8)









Activity 2.4: Comparing energy sources

Time: 30 min

Marks: 7

Imagine yourself in the position of the valley people and draw up a table that compares the advantages and disadvantages for these people of using different energy sources such as burning coal, wood or gas, or using electricity. Use the information in the graphs and any other relevant information. You will be given credit for the information you include, its relevance, how it is arranged, the headings and any units you use.

(7)

Activity 2.5 (EXPANDED OPPORTUNITY)

Work in groups and brainstorm the positives and negatives of using hydro-electric power in South Africa as opposed to generating electricity by burning coal. Each member of the group should make their own list of the outcomes of their brainstorm.

TASK 3 **Activity 3: Destroying the wetland**

Time: 95 min

Marks: 30

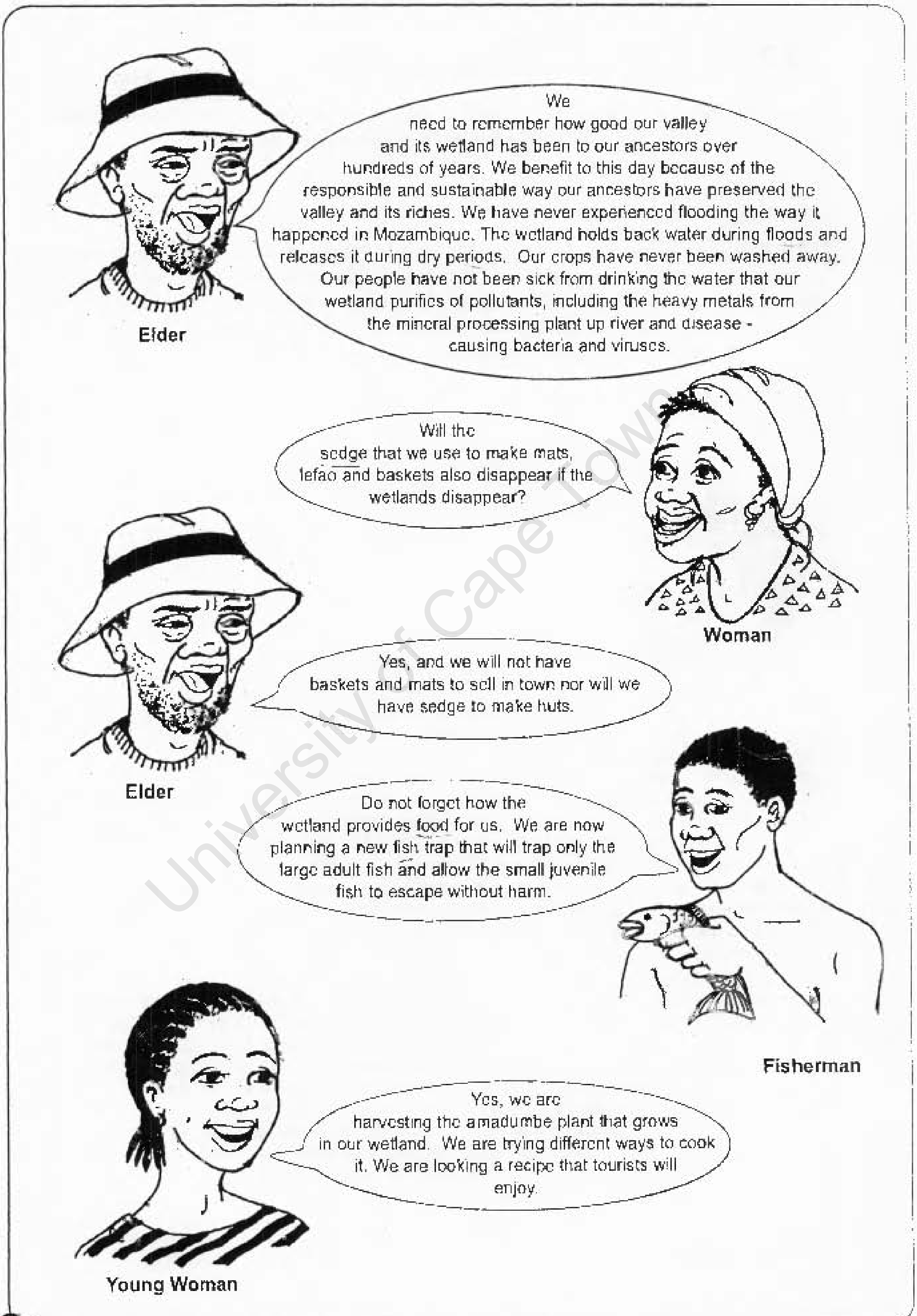
Read "The story of the threatened wetlands" we give below. Read about the meeting of the people living in the valley and about the wetlands that support their lifestyle.

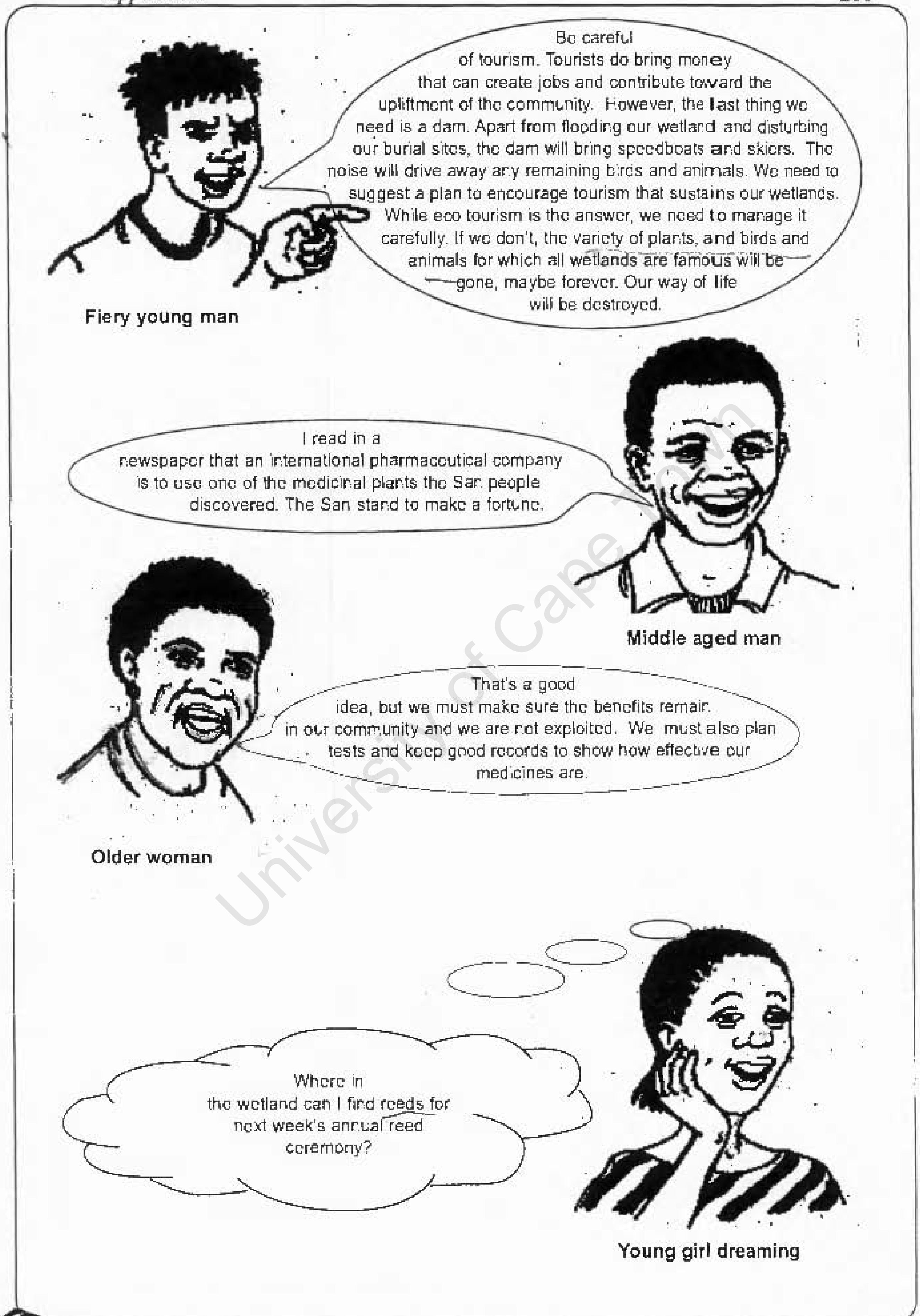
The story of the threatened wetlands.

The community leader called his people to a meeting one evening. He told them of plans an international mining company had to build a dam that would possibly flood their valley, their village and probably destroy their wetland. He became really concerned when he heard that the government liked the idea because they could use the dam to generate hydro-electric power. He stood up and started the meeting by telling them a story.

Traditional healer

Let me tell you about a community that was almost destroyed by the floods in Mozambique in 2000. They lived on the banks of a river below a new dam. As the dam filled the water level level in the river dropped. When the community complained, they were told that there was a drought and when the rains came the river would flow strongly again. They watched as the wetland cried up and the fish died. The reeds they depended on were disappearing. Eventually the rain came and everyone was very happy. The dam started to fill up and the authorities promised to open the sluices of the dam. The the river would soon run strongly again. They dreamt that their wetlands would recover and that the fish, reeds and the birds would return. But the plants in the wetlands had died and the mud had dried and baked hard. The trees had become mere sticks in the ground. As it continued to rain the water rushed over where the wetlands used to be. The rain continued. The water rose up to their homes and the people were scared but still the rain did not stop. Crops were washed away. Homes were flooded. Animals drowned. People were stranded. There was no food and people became sick from drinking the polluted water. Where the road had been, there was only rushing brown water with its burden of flying stones, trees and dead animals. Hunger, thirst and sickness drove some people to try to cross the river but they too were swept away by the rushing water and drowned. The floods in Mozambique in 2000 made headlines across the world. Environmentalists claimed the dams and the resulting destruction of the wetlands were at least partly to blame for the tragedy.


We need to remember how good our valley and its wetland has been to our ancestors over hundreds of years. We benefit to this day because of the responsible and sustainable way our ancestors have preserved the valley and its riches. We have never experienced flooding the way it happened in Mozambique. The wetland holds back water during floods and releases it during dry periods. Our crops have never been washed away. Our people have not been sick from drinking the water that our wetland purifies of pollutants, including the heavy metals from the mineral processing plant up river and disease - causing bacteria and viruses.
Elder
Will the sedge that we use to make mats, lefao and baskets also disappear if the wetlands disappear?
Woman
Yes, and we will not have baskets and mats to sell in town nor will we have sedge to make huts.
Elder
Do not forget how the wetland provides food for us. We are now planning a new fish trap that will trap only the large adult fish and allow the small juvenile fish to escape without harm.
Fisherman
Yes, we are harvesting the amadumbe plant that grows in our wetland. We are trying different ways to cook it. We are looking a recipe that tourists will enjoy.
Young Woman


Be careful of tourism. Tourists do bring money that can create jobs and contribute toward the upliftment of the community. However, the last thing we need is a dam. Apart from flooding our wetland and disturbing our burial sites, the dam will bring speedboats and skiers. The noise will drive away any remaining birds and animals. We need to suggest a plan to encourage tourism that sustains our wetlands. While eco tourism is the answer, we need to manage it carefully. If we don't, the variety of plants, and birds and animals for which all wetlands are famous will be gone, maybe forever. Our way of life will be destroyed.
Fiery young man
I read in a newspaper that an international pharmaceutical company is to use one of the medicinal plants the San people discovered. The San stand to make a fortune.
Middle aged man
That's a good idea, but we must make sure the benefits remain in our community and we are not exploited. We must also plan tests and keep good records to show how effective our medicines are.
Older woman
Where in the wetland can I find reeds for next week's annual reed ceremony?
Young girl dreaming

It was late when they went to bed that night. The people were sure that they did not want to lose their wetland. Vusi drifted off to sleep remembering the story of the serpent with many heads, the guardian of the wetlands. All his life Vusi had been taught to respect the wetlands as the meeting place of land and water. The wetlands are seen as an area that represents the transition between the material and the spiritual world where one's ancestors have a central place. Vusi knew that his health and well-being depend on respect for one's ancestors who can cause both good and bad fortune.

Words used:

Sedge: kind of grass-like plants that grow in wetlands

Lefao: a screen made of reeds

Amadumbe: starchy corms with spinach like leaves.

Interesting facts

Matjiesgoed sedge is able to keep homes cool in summer and warm in winter. In the hot dry weather the culms (or stems) shrink, leaving gaps that allow air to move through the house. In cold, wet weather, the culms swell, closing the gaps, offering protection from cold rain.

Wetlands purify their water by acting as a natural filter. They trap pollutants, including the heavy metals.

During an annual reed ceremony young girls walk past the king, in traditional dress, carrying a reed with the purpose of promoting pride in virginity and respect for young woman.

This text has been adapted from the Mondi Wetlands Project booklet titled Wetlands- water, life, and culture developed in partnership with the Department of Environmental affairs and Tourism; Water Affairs and Forestry and the National Department of Agriculture. Also from the article: Wetlands – treasure troves in Disguise by Michelle Nel.)

Activity 3.1: Understanding concepts related to wetlands

Time: 20 min

Marks: 10 not recorded

Draw a concept map that shows your understanding of the concept 'wetland'.

You will be given credit for:

a) your ability to draw a concept map (This will be assessed by the number and nature of the concepts, the links between the concepts, the linking words you use to show the relationship between the concepts as well as the direction of your arrows linking concepts.)

b) your understanding of the concept 'wetland' as used in this activity and revealed by your concept map

c) your knowledge of the benefits of wetlands as revealed by your concept map

Time: 15 min

Marks: 7

Activity 3.2 The wetland and culture

You have already identified important concepts related to a wetland. The way the people live in the valley will impact on the wetland, and what happens in the wetland will impact on the people. We are particularly interested in the link between the wetland and the culture of the people in the valley.

Show your understanding of the link between the wetland and the culture of the people living in the valley by doing only ONE of the following:

a) Designing a poster

Outline the design of a poster on an A4 page. The contents of the poster must show your understanding of the link between the wetland and the culture of the people living in the valley. You are not required to actually make the poster. The design of your poster will be assessed against the following criteria:

Relevant content

Indicating resources you may want to use

Planning the message

Planning layout

Showing appropriate link between culture and wetlands

OR

b) Write a radio advertisement

You are to write a radio advertisement that will be aired for half a minute on your local radio station. You are not required to present the advertisement. Use the following criteria to help you write your advertisement:

relevant concepts on wetland included

brief and to the point message

not longer than half a minute of air time

highlight important cultural issues and links

exciting and interesting to listeners

(You may want to present your advertisement to your peers outside of class time, but you will only be assessed on the script of the advertisement you submit.)

(7)

Activity 3.3: Identifying and describing an investigation

Time: 30 min

Marks: 8

Identify a potential investigation from The story of the threatened wetlands and

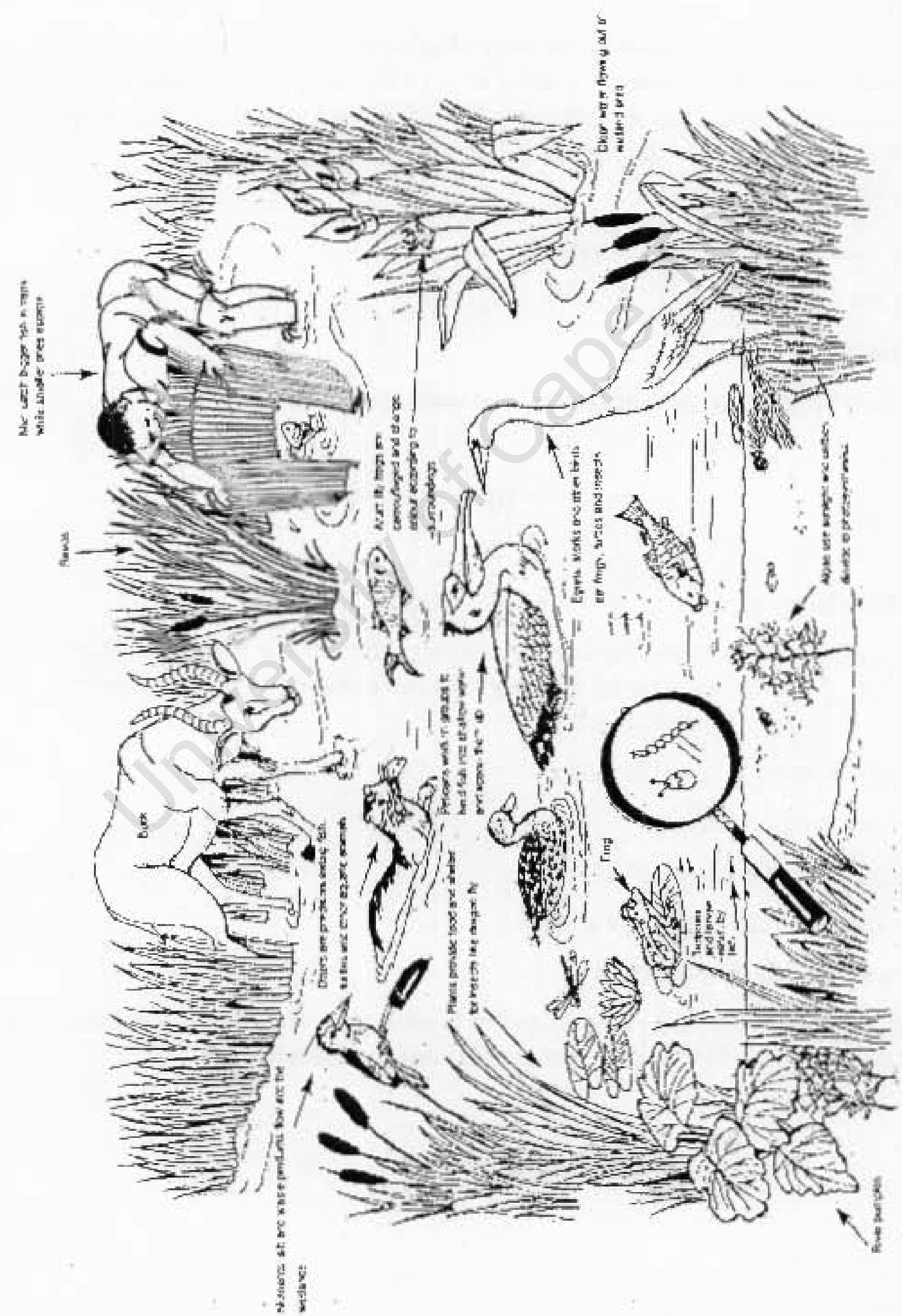
1 write down the question the valley people should investigate;

2 give the variable they should change;

3 give at least two variables they should control; and

4 the variable they should measure in their investigation.

(8)



DEPARTMENT OF EDUCATION

DEPARTMENT OF EDUCATION

NATURAL SCIENCES
(NS)

Common Tasks for Assessment (CTA)
Grade 9
2004

LEARNER'S BOOK

SECTION B

Time: 2hrs

✓ Marks: 80

No. of Pages: 12

THE COMMON TASKS FOR ASSESSMENT (CTA)

PROGRAMME ORGANISER: Sustainable Living

FOCUS: Understanding the importance and functions of water.

Note to the learner:

This CTA consists of a Section A and a Section B. This is section B.

SECTION B:

What you should know:

- You will complete Section B on your own.

What you need:

- You may use a calculator where necessary.

Duration:

- 2 hours.

Instructions:

- Follow the instructions for each question carefully.
- Write your answers on a separate page.

Question 1:
Planning the electrification of a house

✓ Marks: 14

Hans and his sister Sally attend school in Gariepville. They live with their parents in the valley next to the wetlands. Their parents keep cattle and goats and grow vegetables to meet the needs of the family. They sell any extra vegetables in the town. One day the children learn about electricity at school. They are excited to find out they can run a TV (12 V; 24 W) from a 12 V car battery (with a capacity of 40 Amp-hour). When they arrive home, they try to persuade their parents that they need to electrify their house. They tell their parents that they will be able to operate low energy fluorescent lighting (12 V; 12 W tubes) using a battery. They claim this will make it easier for them to study. They tell their father he could even watch soccer on a portable TV.

1.1 To convince their parents the two children draw a circuit diagram showing how they plan to electrify the house. Draw a labelled circuit diagram that the two children can use. Include the following in your diagram: switches, battery, 4 lights (bulbs) and the TV. (4)

1.2 Can the TV be connected in series with the light bulbs? Give two reasons for your answer. (3)

1.3 Do you think the children can use the plug for the TV **to boil water** in a kettle rated at 220 V; 1.5 kW AC? Give a reason for your answer. (2)

1.4 The children priced what they need to carry out their plans.

TV (2nd hand)	R100.00	Solar battery charger	R200.00
4 Flourescent bulbs	R30.00	Switches; plug socket	R50.00
Battery	R300.00	Connectors - scrap	0

The children know their father has R 1000 which he keeps for emergencies. Think of the circumstances in which these children live.

a. In one sentence advise the children as to what you believe they should do. Should they, or should they not, buy these items?

b. In two or three sentences give the most important reason for your advice. (5)

Question 2 An investigation ✓ Marks: 21

To convince their parents that they know about electricity and the investigative method, the children plan an investigation that they can use to show their knowledge and skills. They decide to show their parents that 'pencil lead' is a conductor of electricity which has electrical resistance. This increases with an increase in the length of the piece of pencil lead.

They collect 6 new pencils. 2 of the pencils have 'hard lead' (labelled 2H), 2 'soft lead' labelled HB and 2 very 'soft lead' labelled 2B. They slit the pencils lengthwise to get the 'lead' out. They also have 2H, HB and 2B 'pencil lead' for clutch pencils which are 0.5 mm and 0.7 mm thick.

They borrow two electrical meters from their neighbour who works as an electrician. The electrician sets the one meter to read current in amps and the other to read potential difference (or voltage) in volts.

They set up the circuit as shown in the sketch and record the results indicated in the table.

Symbols for parts of a circuit:

	Length of pencil in circuit (cm)	Voltmeter Volts - (V)	Current Amps (A)	Resistance = voltage / current ohms (Ω)
1	2.5	0.42	0.28	1.5
2	5.0	0.75	0.25	3.0
3	7.5	0.99	0.22	4.5

2.1 Describe a variable that they should control (keep constant). (1)

2.2 Which variable do they change (independent variable)? (1)

2.3 Which variables do they measure using meters? (2)

2.4 Which variable do they calculate? (1)

2.5 Which variable is the dependent variable in their investigation? (1)

2.6 Write down the matter they investigate. (2)

2.7 Describe, in writing, the method they follow to answer the problem they are investigating. Include a circuit diagram. (5)

2.8 Draw a graph of resistance against the length of the pencil lead included in the circuit. Fully label the axes and give your graph a heading. (3)

2.9 Give the conclusion the children reach using the graph of their results. (Give the conclusion in words and mathematical symbols.) (5)

Question 3 Wetland in trouble! ✓ Marks: 20

For many people wetlands are always associated with dampness and disease. To these people it is an advantage to clean up the wetlands and use the water. With such attitudes in common, it is not surprising that our communities do little to conserve wetlands. By 1996 it was estimated that more than half of South Africa's wetlands had disappeared.

Study the picture of "A Wetland in Trouble". Then read the opinions of some of the people with an interest in this wetland that follow.

Stop the pollution! Stop the farming! Move the shack dwellers out. Restore the wetland to its original condition.
Factory Owner
The clean water will once again attract birds and animals. Promote eco-tourism
Bird Watcher
Leave us alone. If any of the ideas these people suggest are tried, they will chase us away and we have no place to go.
Shack Dweller
I can use the wetland to extend my lands and the water to irrigate my crops.
Farmer
Drain this smelly place, and let us use my brother to build houses for the people living in these shacks.
Community Leader
The wetland is only smelly because of the pollution. What we need is sustainable development. If we restore the wetland, we can use it to generate income from farming, agriculture, bird watching and fishing. We can even preserve a precious water resource at the same time.
Official from the department of Environment Affairs
Our children are not safe near this wetland. They always seem to be ill. We think that the wetland should be drained.
Mother
I propose that we drain the wetland and build a shopping mall. The mall will provide job opportunities, convenient shopping and entertainment for young people.

3.1 Give four reasons for preserving wetlands. The reasons you give should make clear your understanding of what a wetland is. (8)

3.2 One way we can describe the underlying problem which makes people a threat to this wetland is the need people have for land, water and shelter.

Give four more problems threatening this wetland. (4)

3.3 Choose one of the underlying problems that you gave in the answer to part 3.2 and list three (or more) steps that you believe should be taken to solve the problem. (3)

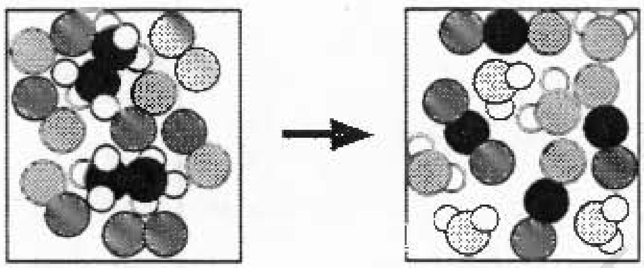
3.4 There are 8 people taking part in the conversation about the wetland above. Read their opinions and decide with which one of the people you agree most. Identify that person (e.g. farmer, community leader, ...) and then describe, in about two or three sentences, why you agree with their argument. (5)

Question 4 Wood or gas? ✓ Marks: 19

Hans and Sally also set out to investigate the feasibility of using gas for heating and cooking instead of wood.

Gas cylinders contain a mixture of gases including ethane and propane.

4.1 One of the ways we can represent the chemical reaction that occurs when ethane burns is using a diagram. Look below for a diagram representing the reaction that occurs when ethane burns.



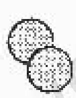
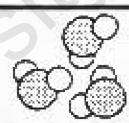
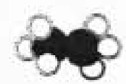
reactants products

Key: ○ ≡ a hydrogen atom - H

● ≡ a carbon atom - C

◌ ≡ an oxygen atom - O

a. Study the following diagrams representing 3 different types and numbers of molecules (A, B and C). Use the key in the above diagram and give a formula for each. (4)

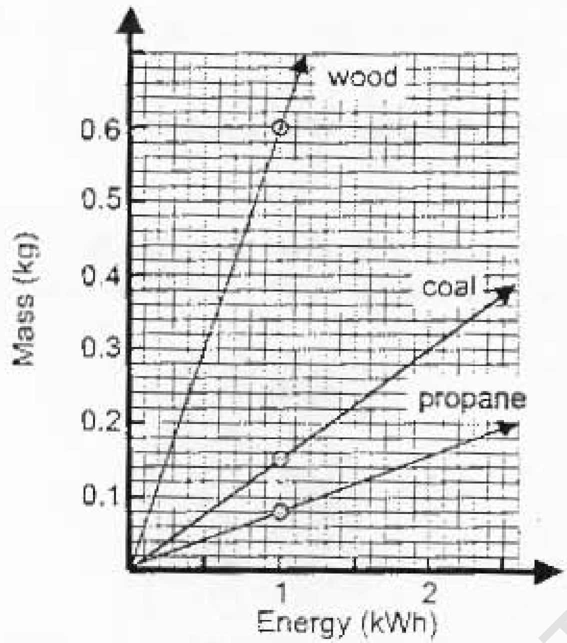
Diagram of molecule			
Formula	A	B	C

b. Use the key given with the diagram and write down a balanced equation for the reaction that occurs when ethane burns. (4)

c. Balance the following equation. (Hint: make your own sketches if that helps.) (2)

$$\_\_\_\_ NO + \_\_\_\_ O_2 \longrightarrow \_\_\_\_ N_2O_5$$

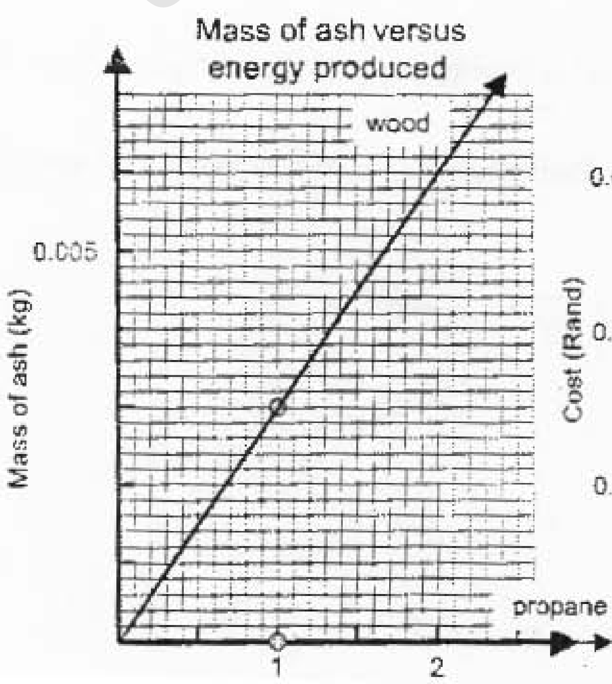
4.2 An advertisement for a gas company contains the following graph.

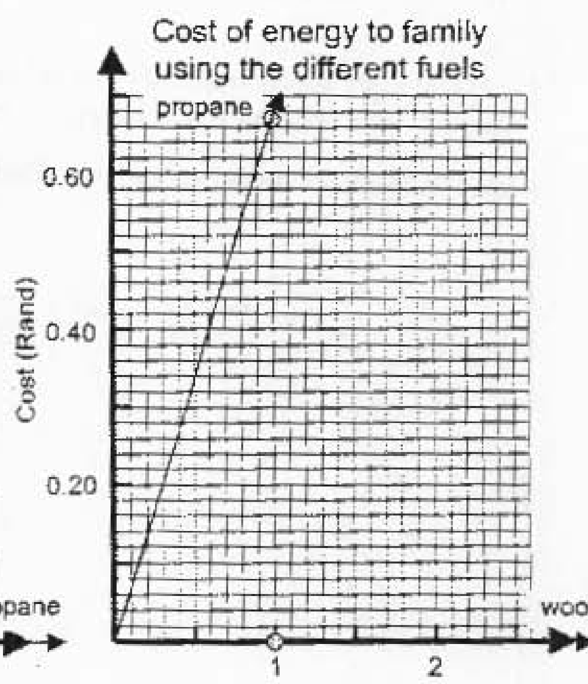


a. Use the information in the graph to draw up a table giving the information conveyed by the graph. You will be given credit for the data you include and how you arrange it, as well as for the headings and any units you use. (4)

b. Use the graph given above, as well as the following two graphs and any other relevant information you have, and

- List one advantage and one disadvantage for the children's family of using wood. (2)
- List one advantage and one disadvantage for the children's family of using propane gas(2)
- List one more advantage or disadvantage for the family of using wood or propane (1) (5)



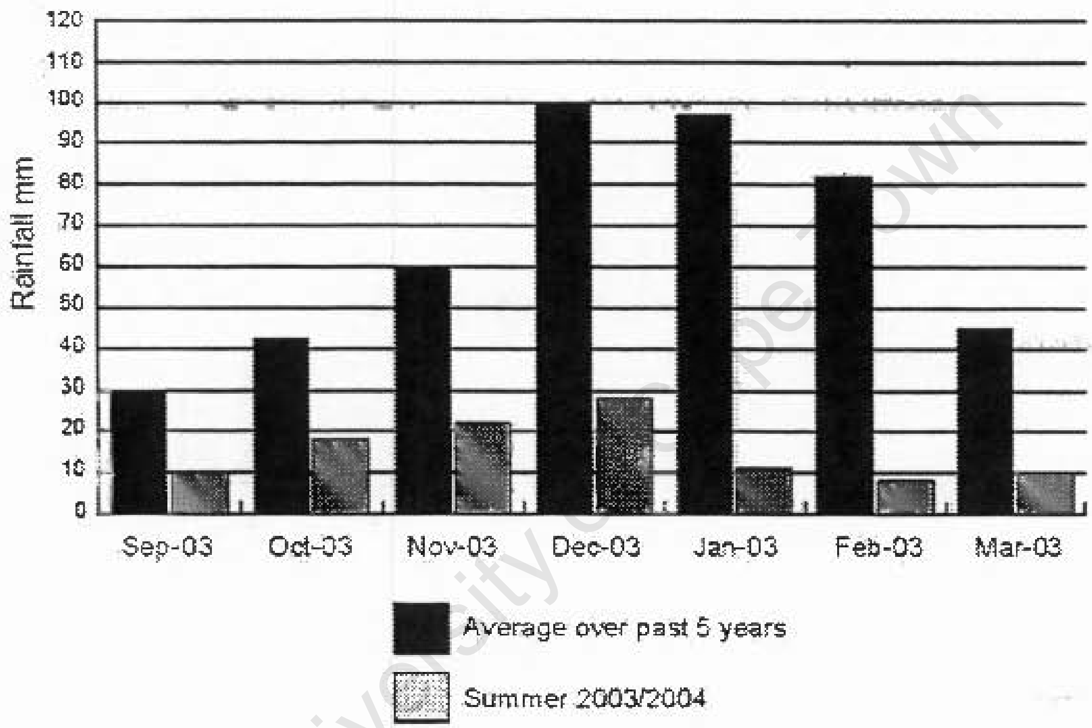


Question 5 Wetlands ✓ Marks: 6

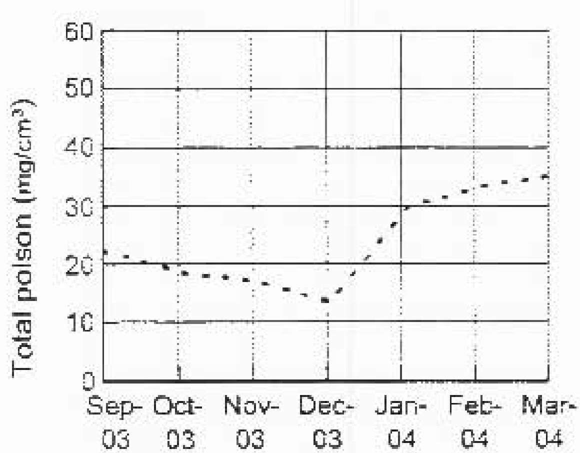
Study the graphs given below.

- Graph A gives the rainfall in the area of the wetland.
- Graph B gives the concentration (mg/cm³) of poison in the water of the wetland.
- Graph C gives a count of the total bird population in the area of the wetland

GRAPH A: Rainfall Patterns

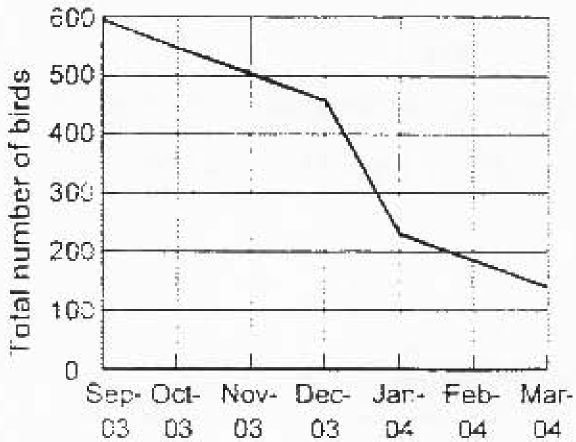


GRAPH B: *Poison levels



* Poison - a substance very dangerous to life and health

GRAPH C: Total number of birds



The factory pumps out a large constant amount of poison continuously into the wetland area.

Explain the influence of the low rainfall in 2003/2004 on the bird population in particular, and on the whole ecosystem in general.

(6)

DEPARTMENT OF EDUCATION

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NATURAL SCIENCES
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Common Tasks for Assessment (CTA)
Grade 9
2004

MEMORANDUM
SECTION B

No. of Pages: 12

ADDITIONAL BACKGROUND INFORMATION:

Below we give more detail and further background information for teachers to be able to confidently explain all the issues even though it is not expected that many learners will give such answers.

Possible supporting arguments include:

The operating voltage is too low **(1)**

To work correctly the kettle requires 220 V to be applied across it. This is impractical but possible. This would require more than eighteen 12 V batteries connected in series (12 x 18 = 216 V).

Issue of AC versus DC (1) (accept the answer: 'No the battery is DC.')

Since the element of a kettle is a resistor, to connect to a source of direct current as opposed to alternating current will not cause a problem.

Energy requirements **(1)**

Energy (W) used by a kettle to raise temperature of 2 ℓ water from 20°C to 100 °C – by 80 °C (tell learners it takes 4 200 J to raise the temperature of 1 kg water 1 °C; this value is known as the specific heat of water):

$$W = \frac{4200\text{ J}}{\text{kg °C}} \times 80\text{°C} \times 2\text{kg} = 672\,000\text{ J}$$

(This is the minimum energy to boil water in kettle once.)

The total energy (W) in a 12 V, 40 Amp-h battery
W = 40 Amp-h x 12 V:

$$W = 40\,\frac{C}{S} \times h \times \frac{60\text{min}}{h} \times \frac{60\text{s}}{\text{min}} \times 12\text{V} = 40\text{ C} \times 60 \times 60 \times 12\,\frac{J}{C} = 1728\,000\text{ J}$$

No. of times the battery will boil water: $\text{No.} = \frac{1\,728\,000}{672\,000} = 2.6$ times

One 12 V, 40 Amp-h battery can only supply the energy required by the kettle to boil water twice before the battery needs to be recharged!

Issues of time **(1)**

How long would it take a 12 V, 40 Amp-hr battery to boil 2 ℓ water in a 1.5 kW 220 V kettle?

Resistance of the kettle:

from $P = IV$ and $I = \frac{V}{R} \Rightarrow P = \frac{V^2}{R}$ and $R = \frac{V^2}{P} = \frac{220^2}{1500} = 32$ ohms

Time to boil 2 _ water in this kettle:

from $W = IVt$ and $I = \frac{V}{R} \Rightarrow t = \frac{WR}{V^2}$ and $t = \frac{672\,000 \times 32}{12^2} = 150\,000\text{s}$

or 2500 min = 42 h (The water would warm up so slowly that it would probably never reach boiling point.)

Issues of Current

Current would not be a problem – a car battery can supply very large currents for a short time.

Rubric for marking 1.2 and 1.3

NSSO5: Use their knowledge of electricity to decide whether a TV and bulb can be connected in series to a 12 V battery. Use their knowledge of electricity to decide whether a 1.5 kW; 220 V AC kettle can be effectively operated using a 12 V DC battery with a capacity of 40 Amp-hour. (AC 6 – Reasons for the decision are communicated.)

MARK ACCORDING TO THE MEMORANDUM ABOVE. The rubric shows how the marks attempt to link to a rate of achievement of the outcome.

	%		Description of rating
1	<35	0-1	1 answer or 1 reason is correct.
2	35-39	2	2 answers correct or 1 answer and 1 reason correct.
3	40-69	3	2 answers correct and 1 reason is correct.
4	>70	4-5	2 answers correct and between 2 and 3 reasons correct.

1.4 The children priced what they need to carry out their plans.

The children know their father has R 1000 saved which he keeps for emergencies. Think of the circumstances in which these children live.

a. In one sentence advise the children as to what you believe they should do.	
Buy the battery, bulbs, TV,	Do not buy the battery, bulbs, TV,
b. In two or three sentences give the most important reason for your advice.	
Buy	Do not buy
1 Allowing the children install and run this system will give them self confidence	1 TV is a luxury they cannot afford
2 The children will have light with which to study	2 They cannot afford recharging and maintenance
3 It gives the children responsibility	3 They have managed without light and TV
4 Parents show trust in the children	4 TV is anti social, they will stop talking to friends
5 Improvements in living standards will lead to a desire for more improvement and innovation and harder work	5 They will have to work harder to make more money to maintain the new life style
6 Light means the day can be extended, productive study and work can be undertaken after dark – they can recoup their father's R 1000 and make more	6 They will have no money for emergencies
7 TV means exposure to new ideas, new knowledge.	

MARK ACCORDING TO THE RUBRIC BELOW.

Rubric for marking 1.4 **(5)**

NSSO9 Demonstrate an understanding of the interaction between the natural sciences and socio-economic developments. (AC 2 – The way in which scientific and technological developments have changed the lives of people analysed.)

	%		Description of rating
1	<35	0-1	Decision given – to buy or not to buy
2	35-39	2	Decision and reason given that do not necessarily correlate.
3	40-69	3	Decision and 1 reason given that correlate.
4	>70	4-5	Decision and 2 or 3 reasons given that correlate.

[14]

Question 2 An investigation

2.1 Describe a variable that they should control. **(1)**
The thickness of the pencil lead.
The type (hardness) of the pencil lead.
Other.

2.2 Which variable will they change? **(1)**
The length of the piece of pencil lead connected in the circuit.

2.3 Which variable(s) will they measure? **(2)**
Voltage across the pencil lead and
the current through the pencil lead.

2.4 Which variable do they calculate? **(1)**
The resistance.

2.5 Which variable is the dependent variable? **(1)**
The resistance.

2.6 Write down the question they wish to investigate. **(2)**
How is the resistance ✓ of 'pencil lead' affected ✓ by its length ✓?
One ✓ correct answer gives 1 mark, for two marks the learner must get all three ✓.

MARK ACCORDING TO THE MEMORANDUM ABOVE. The rubric shows how the marks attempt to link to a rate of achievement of the outcome.

Rubric for marking 2.1 to 2.6
NSSO1 Process skills (AC 2 – Investigative question formulated and variables to be controlled identified.)

	%		Description of rating
1	<35	0-2	Identifies up to two variables of a particular type
2	35-39	3	Identifies up to three variables of a particular type
3	40-69	4 - 5	Identifies up to four variables of a particular type or formulates the investigative question satisfactorily
4	>70	6 - 8	Identifies up to four variables of a particular type and formulates the investigative question satisfactorily

2.7 Describe, in writing, the method they should follow to answer the question they are investigating. Include a circuit diagram.

MARKING:

MARK THE CIRCUIT DIAGRAM ACCORDING TO THE MEMO BELOW:

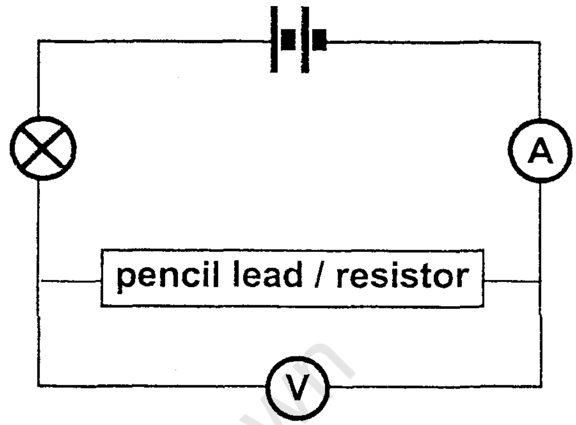
Draw a circuit diagram

There is a complete circuit. (1)

The battery, ammeter and bulb are in series with the resistor. (1)

The voltmeter is across and in parallel with the 'pencil lead' resistor. (1)

One correct answer gives 1 mark; for two marks must get all three answers correct. (2)



NSSO1 Process skills (AC 2 – A plan of action is formulated.)

MARK THE DESCRIPTION OF THE METHOD ACCORDING TO THE MEMO BELOW
(1 mark per point up to a maximum of 3):

Method for the investigation.

1 Vary the length of 'pencil lead' in the circuit (change input variable); (1)

2 Control variables e.g. ensure the hardness and thickness of the pencil lead is always the same. (1)

3 Take voltmeter and ammeter readings; i.e. Record/ measure output variable (resistance is the ratio of V to I) (1) **(5)**

2.8 Draw a graph

MEMO FOR MARKING GRAPH

Correct labels give (1) mark, viz. at least two of *

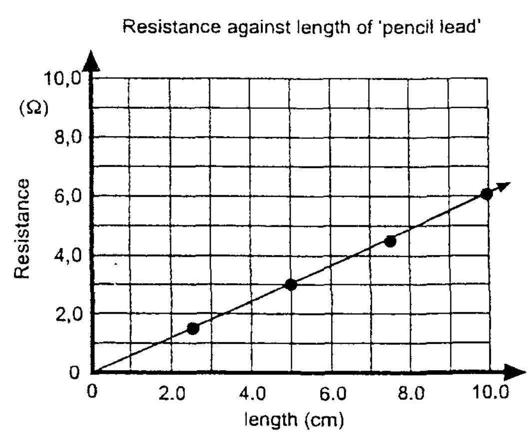
*Appropriate heading

*Appropriate label on 'x-axis' and 'y-axis'

*Appropriate unit on 'x-axis' and 'y- axis'

Suitable scales on 'x-axis' and 'y- axis' (1)

Points plotted correctly and draws straight line (1)



2.9 State a conclusion **(3)**

We do this by answering the question we were investigating, using the results we found from our experiment.

1 The greater the length of the 'pencil lead', the greater the resistance of the 'pencil lead' (1 only)

2 Resistance of the 'pencil lead' is directly proportional to the length of the 'pencil lead'. Relationship in words (2 only)

3 Resistance of the 'pencil lead' is directly proportional to the length of the 'pencil lead' provided the thickness, the type and the temperature are kept constant. Relationship in words plus conditions (3 only)

4 R pencil lead α (length of pencil lead) (a relationship in symbols) (+1)

5 R pencil lead = 0.6 (length of pencil lead) (an equation) (+ 2)

This means a learner who gives 3 and 5 gets 5/5; 3 and 4 gets 4/5, See the rubric for more guidance.

(5)

MARK ACCORDING TO THE MEMORANDUM ABOVE.
The rubric shows how the marks attempt to link to a rate of achievement of the outcome.

	%		**Description of rating**
1	**<35**	**0-1**	**Describes a trend**
2	**35-39**	**2**	**Gives the relationship in one way (words)**
3	**40-69**	**3**	**Relationship in words and symbols, but no equation**
4	**>70**	**4 - 5**	**Relationship in words, plus conditions, plus equation (5)**

Question 3 Wetland in trouble!

3.1 Give reasons for preserving wetlands. The reasons you give should make clear your understanding of what a wetland is.

NSSO2: Acquired knowledge. What are wetlands and what are the reasons for preserving them? (AC 2 – Demonstrate an understanding of the concept 'wetland'.)

MEMO FOR MARKING REASONS FOR PRESERVING WETLANDS (possible responses)

1 Wetlands are water traps that help prevent flooding (1) and Nature's water filter (1)

2 Places that maintain biodiversity (2); OR (1 for each – to a maximum of 2 for) preserve: plants (1), birds (1), fish (1), animals specific to the wetland environment (1)

3 Provide unique types of recreational activities (2); OR (1 for each – to a maximum of 2 for); hiking (1), bird watching (1), fishing (1), boating (1), any other correct answer (1)...

4 A source of unique products – e.g. sedges (2); OR (1 for each – to a maximum of 2 for); (baskets (1), mats (1), house building material (1), any other correct answer (1)...

5 Economic activity (2); OR (1 for each – to a maximum of 2 for); mats (1), baskets (1), fishing (1), tourism (1), medicines (1), any other correct answer (1)...

6 Food source (2); OR (1 for each – to a maximum of 2 for); plants (1), animals (1), fish (1), any other correct answer (1)...

7 Culturally related activities(2); OR (1 for each – to a maximum of 2 for); reed dance (1), medicine (1), any other correct answer (1)...

2 marks for each of points 1 to 7 (or any other valid point) to a maximum of four points and 8 marks. **(8)**

3.2 One way we can describe the underlying problem that makes people a threat to this wetland is the need people have for land, water and shelter.

Give 4 problems threatening this wetland. (Four additional (to people's need for land, shelter and water) threats to this wetland.)

MEMO FOR MARKING – GIVE ONE MARK FOR A CLEAR STATEMENT OF EACH PROBLEM IDENTIFIED

1 Chemical pollution; economic development, industrial development leads to more factories and pollution from factories – industrial waste and chemical impurities; poisonous substances dumped into the water

2 Contamination with nitrogen rich fertilizers running off agricultural land causing growth of algae

3 Contamination with pesticides running off agricultural land and poisoning the water

4 Invasion by exotic plants which drain the wetland of water

5 Invasion by animals, farm and domestic

6 The draining of the wetland (drying up the wetland) The need for jobs and increasing industrial output also increases use of water by industry, which already uses more water than agriculture. This creates a threat to use the water.

7 The draining of the wetland (drying up the wetland) The need for increased food production, a need for more farming, a need for more water and increased irrigation, creates a threat to drain the wetland of its water.

8 Biological pollution, untreated sewage, dead animal and vegetable matter in quantities with which the wetland cannot cope

9 Invasion by humans Increased need for diverse recreational opportunities – possibility that the wetland can be over run by fisherman, boatman, birdwatchers, hikers, ...

10 Any other correct answer

(4)

3.3 Choose one of the underlying problems that you gave in the answer to part 3.2 and list three (or more) steps that you believe should be taken to solve the problem.

Three steps to solve the problem

MEMO FOR MARKING – GIVE ONE MARK FOR A CLEAR STATEMENT OF EACH STEP TO SOLVING THE PROBLEM

EXAMPLE: Underlying problem selected: Industrial pollution

Three ways to solve the underlying problem;

1 Law: Ensure that there are laws in place to stop dumping of waste of any kind into wetland; this includes certain pesticides by farmers;

2 Policing: Need for policing to enforce the laws

3 Resources to police – a programme of ongoing water testing for chemical and biological contamination as well as water quality; on site inspections to ensure no dumping,

4 Prevention: Need for chemical plants to remove chemical impurities and for biological purification plants to treat plant and animal waste so that they do not get into the water in the first place.

5 Education: Change people's attitudes – provide information and encourage responsible use of wetlands by industrialists

6 Any other

(3)

3.4 There are 8 people taking part in the conversation about the wetland above. Read their opinions and decide with which person you agree most. Identify that person (e.g. farmer, community leader, ...) and then describe, in about two or three sentences, why you agree with their argument.

(5)

MARK USING THE RUBRIC

Rubric for marking 3.4
NSSO5. Use scientific knowledge to support responsible decision-making. Learners are given the opportunity to identify with the responsible decision and justify their choice. (AC 5 & 6 – Alternatives are considered and reasons for decisions communicated.)

MEMO – CRITERIA TO USE TO ASSESS THE LEARNER'S RESPONSE

The solutions the eight people propose vary according to

- The extent to which they themselves benefit
- The number of people that will benefit
- The extent to which they propose a short or long term solution

MEMO Possible answer This answer is worth 5/5:

Person with whom I agree most: Official from DEA
Reasons for agreeing with official from the DEA:
1 Sustainable development is the key – long term
2 Most people come out winners – it is a sensible compromise.

MEMO - MARKING: Use the reasons the learner gives for identifying with the particular person to give them a particular rating on the rubric.

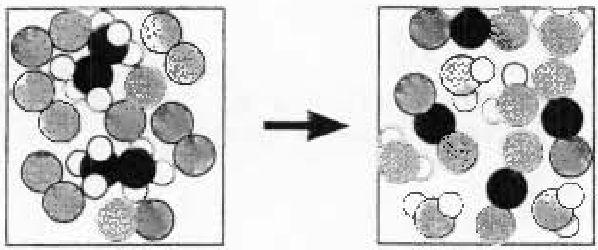
	%		Description of rating The learner identifies with a solution that benefits ...
1	<35	0-1	only the proposer and is short term (e.g. farmer, community leader)
2	35-39	2	the proposer and one or two more and is short term (e.g. business woman, mother)
3	40-69	3	the proposer and one or two more and has long term possibilities (e.g. birdwatcher)
4	>70	4-5	many different interest groups and is really long term (e.g. DEA official)

[20]

Question 4 Wood and Gas

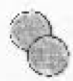
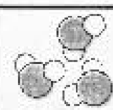
4.1 Study the following diagram representing the reaction that occurs when ethane burns

a. Write a formula to represent the sketches of molecules in the table below.



Key: ○ ≡ a hydrogen atom - H
● ≡ a carbon atom - C
◎ ≡ an oxygen atom - O

NSSO2: Demonstrate an understanding of chemical formulae. (4)

Diagram of molecule			
Formula	(A) O_2 ✓	(B) $3H_2O$ ✓ ✓	(C) C_2H_6 ✓

b. Write down a balanced equation that occurs when ethane burns.

$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

1 mark for each coefficient (ie 2, 7, 4 and 6 each receive 1 mark)

(4)

c. Balance the following equation.

$4NO + 3O_2 \rightarrow 2N_2O_5$

1 for one element balanced; 2 for balancing N and O

(2)

4.2 An advertisement for the gas company contains a graph.

a. Draw up a table giving the information in the graph.

MEMO - ANSWER

Mass of Various Substance with an Energy Content of 1 kWh

Substance	Energy / kWh	Mass / kg
Propane	1	0,08
Coal	1	0,15
Wood	1	0,60

NSSO1: Demonstrate the skill required to draw up a table from a graph.

1 Appropriate columns used and headings are identified

and

Appropriate rows used and titles are identified (1)

2 The correct units are used with headings (1)

3 All three data points are correct (1)

4 The table has an appropriate heading. (1)

(4)

b. Use the graph given above, as well as the two graphs below and any other relevant information you have, to answer the following question.

List the advantages and disadvantages for the children's family of using wood or propane gas for heating and cooking.

NSSO1: AC 5 Data are analysed, evaluated and interpreted

MEMO – POSSIBLE ANSWERS

	The change – family from using wood to using gas (propane)			
	Advantages		Disadvantages	
	Wood	Propane gas	Wood	Propane gas
1 Mass required		Small	large	
2 Cost	nil			Expensive
3 Convenience		Available	Collection time	
4 Cleanliness		No ash	Ash	
5 Pollution		No smoke	Smoke	
6 Safety	Safe	Safe		
7 Equipment	None			Cylinder, cooker,
8 Time of use		Quick	Slow	
9 Storage		Little space	Dry space	
10 Versatility		Heat, light, refrigeration,	Heat only	
11 Any other				

MARKING

1 mark per advantage / disadvantage for wood or gas to a maximum of 5
e.g. This answer is worth 5/5

Disadvantages of propane are expense (1), need for extra equipment, cylinder, gas cooker, (1)

Advantages of wood are cost (nil – collect in veld) (1), no extra equipment needed (1)

Disadvantage of wood is the time to collect (1)

(5)

Question 5: Wetlands

(6)

Use the information given above to explain the link between the influence of the low rainfall in 2003/2004 and the bird population, as well as its influence on the whole ecosystem.

Possible answers

Low rainfall causes less water in the wetland area. (1)

Poisons will become more concentrated (1) with the continuous flow of waste (same quantity of poison) (1) from the factory into the wetland area.

Higher concentrations of poison in the water will mean animals drinking the same quantity of water consume more poison. (1)

More poison will lead to the death of small animals (1).

Less food will be available in the food chain. (1)

More poison will accumulate in secondary consumers (1).

This leads to the decrease in numbers of secondary consumers like birds (They may die; (1) birds will be affected first and they might migrate (1).)

The whole ecosystem will be disturbed (1). Algae might increase, using up more oxygen in the water, primary consumers will disappear leading to a complete collapse in the ecosystem.

Man will also be affected negatively.

MARK ACCORDING TO THE MEMORANDUM ABOVE. 1 mark per point to a maximum of 6. The rubric shows how the marks attempt to link to a rate of achievement of the outcome.

Rubric for question 5 (6)

Level		Marks	Level descriptors
1	<35	0-2	Able to read and interpret up to two of the graphs but makes no plausible links between the graphs.
2	35-39	3	Able to read and interpret the 3 graphs but makes no plausible links between the graphs. Provides no supporting arguments. Unable to draw conclusions.
3	40-69	4	Is able to read and interpret the graphs and make at least one relevant and plausible link between two of the graphs.
4	>70	5-6	Is able to read, interpret graphs correctly. Provide a plausible explanation and can draw conclusions. Able to structure an argument to support his answer.

APPENDIX 2

CLASSIFICATION OF THE SEVENTEEN PROCESS SKILLS, LEARNING OUTCOMES AND ASSESSMENT STANDARDS PRESENT IN THE NATURAL SCIENCE COMMON TASKS FOR ASSESSMENT (CTA) GRADE 9 : 2004

Table 3.1: Classification of the 25 CTA (2004) items according to process skills, outcomes and assessment standards.

Item	Learning Outcomes	RNCS Process Skills	RNCS Assessment Standards
1.1	LO1	• Communicating science information, e.g. constructing a circuit by using information given, i.e the switches, battery, four light bulbs and the T.V	
	LO2	• The learner recalls meaningful information (intellectual skill)	• The learner recalls previous knowledge, e.g. based on previous knowledge, the learner is able to connect bulbs in parallel and to draw a circuit (9.2.1). • Application, e.g. the learner uses knowledge of circuits to draw a labeled circuit diagram (unfamiliar problems) (9.2.4).
1.2	LO2	• Decision making • Recall meaningful information (intellectual skill)	• The learner recalls meaningful information, e.g. the learner recalls knowledge of parallel and series connections learnt in class (9.2.1). • Application of knowledge, e.g. the learner applies knowledge of electricity, i.e. series or parallel connection with light bulbs and T.V. (9.2.4).
1.3	LO2	• Decision making • Recall meaningful information (intellectual skill)	• The learner recalls meaningful information, e.g. learner has to know something about voltage and alternating current (9.2.1). • Interpreting information, e.g. learner has to interpret the passage that has been given on the different appliances and voltage used in order to make a decision (9.2.3).
1.4	LO1	• Interpreting information • Observing and comparing	• The learner evaluates data and communicates findings, i.e. learner makes sense of the expenses to be made to purchase the appliances and

	LO3	• Decision making i.e. learners have to decide whether to use the items or not, taking into account their father's financial position.	decides whether it is a good or bad thing in the interest of the family (9.12). • Education should help learners to become problem solvers.
2.1	LO1 LO2	• Planning science investigations, e.g. describing a variable that they should control,.i.e. identifying variables. • Classifying and sorting, i.e. learner sorts and classifies the different variables used during the investigation. • Interpreting information e.g.the learner is able to make sense of the written paragraph by describing which variable needs to be controlled.	• Planning science investigations, i.e. learner effectively controls at least one variable during data collection (9.1.2). • Plans a procedure to test predictions or hypothesis, with control of an interfering variable (9.1.1).
2.2	LO1 LO2	• Planning science investigations e.g. planning how to change one variable and keep the other constant (hypothesising inferrered) • Interpreting information e.g. to interpret information from the table to decide predict which variable will change. (hypothesising inferred)	• Conducts investigations i.e. learner has to decide which variable they have to change (9.1.2). • Interprets information by extrapolating from patterns in tables to predict how one variable will change (9.2.3). • Interpreting information e.g. to interpret information from the table in order to predict which variable will change.
2.3	LO1	• Planning science investigations e.g. choosing the variables that they have to measurei.e. identifying variables	• Plans investigations i.e. identifies the variables that they have to measure (9.1.1).

	LO2	• Interpreting information e.g . learner has to make sense of information given in order to choose the variable that needs to be measured • (hypothesizing is inferred)	• Interpreting information e.g. to interpret information from the table in order to predict which variable needs to be measured (9.2.3).
2.4	LO1 LO2	• Planning science investigations e.g. deciding which variable should be calculated • Hypotesising is inferred • Interpreting information e.g. learner has to make sense of information given to choose which variable to calculate	• Plans investigations i.e. identifies the variables that they have to calculate (9.1.3). • Interpreting information e.g. to interpret information from the table in order to predict which variable needs to be calculated (9.2.3).
2.5	LO1 LO2	• Planning science investigations e.g deciding which variable is the dependent variable (resistance) • Interpreting information e.g. learner has to make sense of information given to identify the dependent variable	• Plans investigations i.e. identifies the variables that they have to measure(9.13). • Interpreting information e.g. learner has to make sense of information given to identify the dependent variable (9.2.3).

2.6	LO1	• Planning science investigations e.g. learner clarifies focus question for investigation i.e. how is the resistance of the 'pencil lead' affected by its length?	• Planning science investigations e.g. learner clarifies focus question for investigation (9.1.1).
	LO2	• Interpreting information e.g. making sense of the information to write down the matter to be investigated i.e raising questions about a situation • Raising questions about a situation e.g. how is the resistance of 'pencil lead' affected by its length?	• Interpreting information e.g. learner has to interpret information given by the investigation in order to give the aim of the investigation (9.2.3).
2.7	LO1	• Planning science investigations e.g. developing a method for the investigation	• Planning science investigations e.g. writing down thw method for the investigation (9.1.2).
	LO2	• Interpreting information e.g using the given information to describe a method to be used i.e. Vary length of pencil lead; control variables taking; voltmeter and ammeter readings. • Communicating science information e.g. constructing a circuit diagram in describing the method used in answering the problem they wish to investigate i.e. how is the resistance of 'pencil lead' affected by its length?	• Interpreting information e.g. learner has to interpret information given by the investigation in order to be able to write down the method (9.2.3).
2.8	LO1	• Planning science investigations e.g. learner draws a graph of resistance against the length of the pencil lead to represent the data	• Evaluates data and communicates findings i.e. learner presents data in suitable form to show trends and patterns (9.1.3).
	LO2	• Communicating science information e.g. drawing a graph of resistance against the length of the pencil lead Recording information e.g. learner uses a graph to represent the data given.	• Interpreting information i.e. translates tables into line graphs (9.2.3).

	LO3	• Applies knowledge i.e. learner uses knowledge of wetlands and applies it to the particular question • Problem solving i.e. learner has to identify four more problems that is a threat to the wetlands	• Applies knowledge: applies principles and links relevant concepts to generate solutions to somewhat unfamiliar problems (9.2.4). • Understands the sustainable use of the earth's resources i.e.learner responds appropriately to knowledge about the use of resources and environmental impacts (9.3.2).
3.3	LO2 LO3	• Applies knowledge i.e learner uses knowledge of wetlands and applies it to the particular question • Problem solving i.e. learner has to decide on three steps that should be taken to solve the identified problem.	• Interprets information i.e.generates own sentences (9.2.3). • Understands the sustainable use of the earth's resources i.e learner responds appropriately to knowledge about the use of resources and environmental impacts (9.3.2).

2.9	LO1 LO2	• Communicating science information e.g.learners reports on the investigation by drawing a conclusion • Application of a formula, i.e. proportionality. • Interpreting information e.g.making an inference from given information from the experiment i.e. the graph of resistance against the length of the pencil lead and the table to draw a conclusion	• Evaluates data and communicates findings i.e. seeks patterns and trends in the data collected and generalisie in terms of simple principles (9.1.3). • Interprets information i.e. by identifying relationships between variables from tables and graphs of data (9.2.3).
3.1	LO2 LO3	• Recall meaningful information e.g. learner has the opportunity to recall information on wetlands. • Interpreting information e.g. learner has to explain in his or her own words reasons for preserving the wetland • Sorting information e.g. learner has to sort out the information given. • Problem solving e.g. learner is able to give reasons for preserving the wetlands	• Recall meaningful information when it is needed (9.2.1). • Interpreting information i.e. own sentences are generated from text (9.2.3). • Understands the sustainable use of the earth's resources i.e.learner responds appropriately to knowledge about the use of resources and environment impacts (9.3.2).
3.2	LO2	• Interpreting information e.g. changing the form of information, from the picture given portraying the problems threatening the wetland into sentences • Recall meaningful information	• Interpreting information i.e. learner generates own sentences from text (9.2.3). • Recall meaningful information when it is needed (9.2.1).

4.2a	LO1	• Sorting and classifying • Communicating science information i.e. learner translates the information given by the graph into a table. • Interpreting information i.e. learner changes form of information to another form i.e from line graph to table form	• Evaluates data and communicates findings i.e. presents data in suitable forms in order to show trends and patterns (9.1.3).
4.2b1	LO1	• Interpreting information. e.g. The learner makes an inference by using the given information i.e. listing one advantage and disadvantage for the children's family for using wood • Evaluates data i.e. learner has to evaluate the line graph in order to list the advantage or disadvantage for the children's family for using wood	• Evaluates data and communicates findings
	LO2	• Interpreting information. e.g. The learner makes an inference by using the given information i.e. listing one advantage and disadvantage for the children's family for using propane gas	• Interprets information i.e. interprets information by translating line graphs into text (9.2.3)
	LO1	• Evaluates data i.e. learner has to evaluate the line graph in order to list the advantage or disadvantage for the children's family for using propane gas	• Evaluates data and communicates finding (9.1.3)
4.2b2	LO1	• Interpreting information. e.g. The learner makes an inference by using the given information i.e. listing one more advantage or disadvantage for the children's family for using propane or wood. • Evaluates data i.e. learner has to evaluate the line graph in order to one more advantage or disadvantage for the children's family for using propane or wood	
	LO2		• Interprets information i.e. interprets information by translating line graphs into text (9.2.3)
4.2b3	LO1	• Interpreting information e.g. The learner makes an inference by using the given information i.e. listing one more advantage or disadvantage for the children's family for using propane or wood.	

3.4	LO2 LO3	• Interpreting information i.e. learner reads through the passage given and after his /her interpretation of the passage, has to decide with which one he/she agrees most • Justifying an argument i.e. learner has to choose the person that he/she agrees with most and has to justify their choice.	• Interprets information i.e. generates own sentences (9.2.3). • Applies knowledge i.e. apples principlesw and links relevant concepts to generate solutions to somewhat unfamiliar problems (9.2.4). • Understands science as a human endeavour i.e. recognizes differences in explanations offered by the Natural Sciences Learning Area and other systems of explanation i.e identifies sources and nature of authority in two differing explanations for an event (9.3.1). • Understands sustainable use of earth's resources: responds appropriately to use of resources and environmental aspects (9.3.2).
4.1a 4.1b 4.1c	LO2 LO2 LO2	• Interpreting information e.g the learner uses what has been given to him/her i.e. the diagrams with the atoms, the learner will be able to use the key to develop a formula for each molecule. • Recalling meaningful information e.g. learner has to know what the ethane formula is from section A and to understand what occurs when ethane burns i.e use oxygen. • Applies knowledge i.e learner uses the key given with the diagram to write down a balanced equation for the reaction that occurs when ethane burns. • Applies knowledge	• Recalls meaningful information i.e at the minimum, learner recalls principles, processes and models (9.2.1). • Recalls meaningful information i.e at the minimum, learner recalls principles, processes and models (9.2.1). • Applies knowledge i.e applies principles and links relevant concepts to generate solutions to somewhat unfamiliar problems (9.2.4). • Applies knowledge i.e applies principles and links relevant concepts to generate solutions to somewhat unfamiliar problems (9.2.4).

	LO2	• Evaluates data i.e. learner has to evaluate the line graph in order to give one more advantage or disadvantage for the children's family for using propane or wood.	• The learner interprets information i.e. interprets information by translating line graphs into text (9.2.3)
5	LO1 LO2 LO3	• Interpreting information i.e. learner makes an inference after evaluating the graphs. • Communicating science information i.e. learners use the line graphs to be able to list one more advantage or disadvantage for the children's family for using propane or wood. • Interpreting information i.e. learner makes an inference after evaluating the graphs.	• Evaluates data and communicates finding (9.1.3) • Interprets information i.e. interprets information by translating line graphs into text (9.2.3) • Applies knowledge i.e. learner applies principles and links relevant concepts to generate solutions to somewhat unfamiliar problems (9.2.4) • Understands sustainable use of the earth's resources (9.3.2)

APPENDIX 3

GRADE 9 LEARNERS' MEAN SCORES FOR EACH ITEM (PILOT STUDY)

Variable	Descriptive Statistics (PILOT STUDY 3 SCHOOLS)				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Q1.1	511	1.37	0.00	4.00	1.45
Q1.2	511	1.17	0.00	3.00	1.13
Q1.3	511	1.21	0.00	2.00	0.87
Q1.4	511	2.18	0.00	5.00	1.32
Q2.1	511	0.20	0.00	1.00	0.40
Q2.2	511	0.32	0.00	1.00	0.47
Q2.3	511	0.61	0.00	2.00	0.86
Q2.4	511	0.45	0.00	1.00	0.50
Q2.5	511	0.21	0.00	1.00	0.41
Q2.6	511	0.46	0.00	2.00	0.73
Q2.7	511	0.80	0.00	4.00	1.02
Q2.8	511	1.01	0.00	3.00	1.27
Q2.9	511	1.61	0.00	5.00	2.13
Q3.1	511	3.75	0.00	8.00	3.07
Q3.2	511	1.77	0.00	4.00	1.37
Q3.3	511	1.31	0.00	3.00	1.16
Q3.4	511	2.04	0.00	5.00	1.44
Q4.1a	511	1.62	0.00	4.00	1.35
Q4.1b	511	0.98	0.00	4.00	1.61
Q4.1c	511	0.45	0.00	2.00	0.80
Q4.2a	511	1.43	0.00	4.00	1.49
Q4.2b1	511	0.87	0.00	2.00	0.91
Q4.2b2	511	0.76	0.00	2.00	0.92
Q4.2b3	511	0.35	0.00	1.00	0.48
Q5	511	1.83	0.00	6.00	1.91

APPENDIX 4

GRADE 9 LEARNERS' MEAN SCORES FOR SCHOOLS A, B AND C

Item	SCHOOL A:MEAN VALUES Valid N	Mean	Minimum	Maximum	Std.Dev.
1.1	150	2.84	0.00	4.00	1.04
1.2	150	1.95	0.00	3.00	1.06
1.3	150	1.67	0.00	2.00	0.66
1.4	150	3.62	0.00	5.00	1.10
2.1	150	0.29	0.00	1.00	0.45
2.2	150	0.57	0.00	1.00	0.50
2.3	150	0.99	0.00	2.00	0.94
2.4	150	0.63	0.00	1.00	0.49
2.5	150	0.38	0.00	1.00	0.49
2.6	150	0.94	0.00	2.00	0.80
2.7	150	1.69	0.00	4.00	0.87
2.8	150	2.41	0.00	3.00	0.91
2.9	150	4.34	0.00	5.00	1.58
3.1	150	6.60	0.00	8.00	1.51
3.2	150	2.66	0.00	4.00	0.95
3.3	150	2.40	0.00	3.00	0.74
3.4	150	3.77	0.00	5.00	1.04
4.1(a)	150	2.54	0.00	4.00	1.22
4.1(b)	150	2.31	0.00	4.00	1.72
4.1(c)	150	1.09	0.00	2.00	0.93
4.2(a)	150	2.78	0.00	4.00	0.90
4.2(b)1	150	1.78	0.00	2.00	0.52
4.2(b)2	150	1.77	0.00	2.00	0.58
4.2(b)3	150	0.77	0.00	1.00	0.42
5	150	3.58	0.00	6.00	1.57

Item	SCHOOL B: MEAN VALUES				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
1.1	121	1.52	0.00	4.00	1.35
1.2	121	1.51	0.00	3.00	1.08
1.3	121	1.45	0.00	2.00	0.77
1.4	121	1.82	0.00	3.00	0.72
2.1	121	0.22	0.00	1.00	0.42
2.2	121	0.42	0.00	1.00	0.50
2.3	121	0.89	0.00	2.00	0.94
2.4	121	0.74	0.00	1.00	0.44
2.5	121	0.31	0.00	1.00	0.47
2.6	121	0.56	0.00	2.00	0.75
2.7	121	1.08	0.00	4.00	1.01
2.8	121	1.12	0.00	3.00	1.13
2.9	121	1.32	0.00	4.00	1.29
3.1	121	5.25	0.00	8.00	2.75
3.2	121	2.35	0.00	4.00	1.31
3.3	121	1.40	0.00	3.00	1.11
3.4	121	1.87	0.00	4.00	0.80
4.1(a)	121	1.98	0.00	4.00	1.24
4.1(b)	121	1.22	0.00	4.00	1.75
4.1(c)	121	0.47	0.00	2.00	0.82
4.2(a)	121	1.98	0.00	4.00	1.30
4.2(b)1	121	0.98	0.00	2.00	0.88
4.2(b)2	121	0.83	0.00	2.00	0.87
4.2(c)3	121	0.48	0.00	1.00	0.50
5	121	2.46	0.00	6.00	1.66

Item	SCHOOL C: MEAN VALUES				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
1.1	240	0.38	0.00	3.00	0.75
1.2	240	0.52	0.00	2.00	0.73
1.3	240	0.80	0.00	2.00	0.84
1.4	240	1.47	0.00	4.00	0.90
2.1	240	0.13	0.00	1.00	0.34
2.2	240	0.11	0.00	1.00	0.31
2.3	240	0.23	0.00	2.00	0.56
2.4	240	0.19	0.00	1.00	0.39
2.5	240	0.05	0.00	1.00	0.22
2.6	240	0.10	0.00	2.00	0.43
2.7	240	0.10	0.00	3.00	0.44
2.8	240	0.07	0.00	3.00	0.41
2.9	240	0.05	0.00	3.00	0.29
3.1	240	1.21	0.00	8.00	1.51
3.2	240	0.92	0.00	4.00	1.09
3.3	240	0.58	0.00	3.00	0.79
3.4	240	1.03	0.00	5.00	0.73
4.1(a)	240	0.86	0.00	4.00	1.02
4.1(b)	240	0.03	0.00	4.00	0.29
4.1(c)	240	0.04	0.00	2.00	0.23
4.2(a)	240	0.30	0.00	4.00	0.88
4.2(b)1	240	0.25	0.00	2.00	0.57
4.2(b)2	240	0.10	0.00	2.00	0.37
4.2(b)3	240	0.02	0.00	1.00	0.13
5	240	0.42	0.00	5.00	0.88

APPENDIX 5

AN EXPLORATORY FACTOR ANALYSIS OF THE RESPONSES TO THE 25 ITEMS TESTED AT THE THREE SCHOOLS A, B AND C

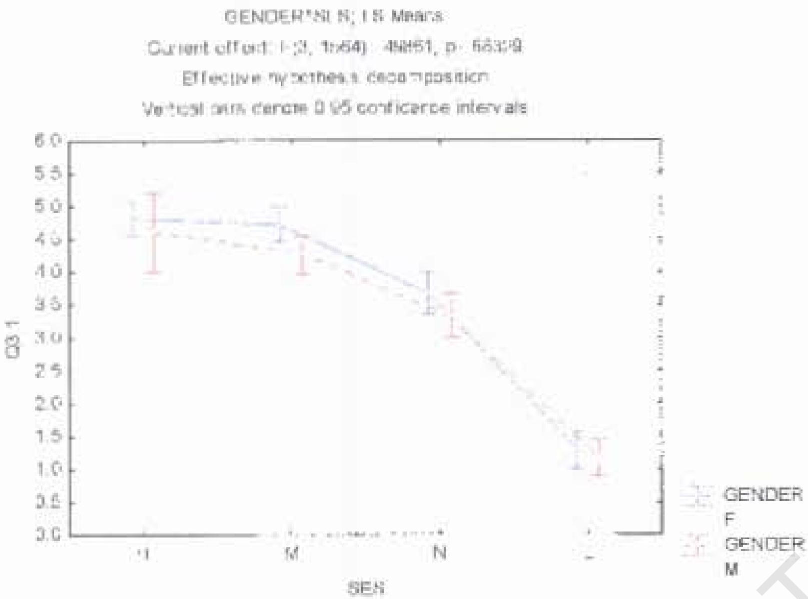
	Factor Analysis of the 25 CTA items of the three pilot schools .			
Variable	Factor 1	Factor 2	Factor 3	Factor 4
1.100000	0.469	0.176	0.295	0.389
1.200000	0.180	0.037	*0.580*	0.106
1.300000	0.102	-0.003	*0.622*	0.054
1.400000	*0.502*	-0.144	0.484	-0.074
2.100000	-0.005	*0.688*	-0.025	0.041
2.200000	0.173	0.292	0.168	0.500
2.300000	0.141	0.088	0.093	*0.680*
2.400000	0.202	0.086	0.115	*0.724*
2.500000	0.075	*0.640*	0.035	0.226
2.600000	0.206	0.394	0.324	0.204
2.700000	0.369	0.283	0.298	0.413
2.800000	0.473	0.455	0.379	0.168
2.900000	0.471	0.449	0.448	-0.053
3.100000	*0.561*	0.255	0.397	0.143
3.200000	*0.659*	0.206	-0.061	0.243
3.300000	*0.694*	0.149	0.104	0.213
3.400000	*0.666*	-0.079	0.239	0.151
4.1(a)	0.310	-0.007	*0.507*	0.364
4.1(b)	0.209	0.197	*0.627*	0.322
4.1©	0.169	0.235	*0.567*	0.200
4.2(a)	0.472	0.315	0.287	0.278
4.2(b)1	*0.699*	0.081	0.226	0.224
4.2(b)2	*0.646*	-0.005	0.372	0.238
4.2(b)3	*0.505*	0.084	0.430	0.009
5.000000	*0.522*	0.252	0.385	0.219

NOTE 1: This factor analysis was carried out because intact data was available from the three schools in the pilot study (phase 1). In phase 2 only incomplete data due to time constraints was available from all the 12 schools which were part of the stratified sampling procedure in phase 2 of the investigation.

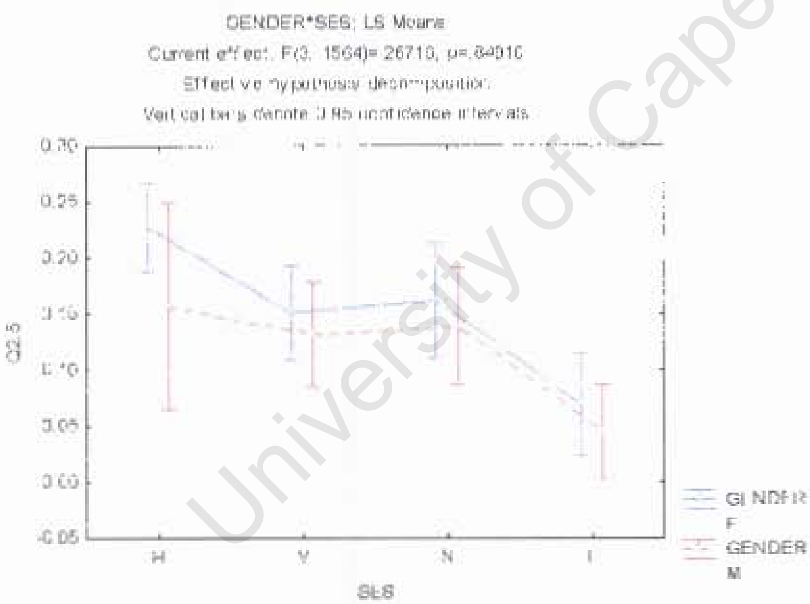
NOTE 2: A correlation coefficient of r=0.61 (n=64) for a predictive validity estimate was obtained between two Grade 9 classes' CTA scores and their learners' marks on the June 2004 school science examination papers. This value was statistically significantly (p<0.01).

APPENDIX 6

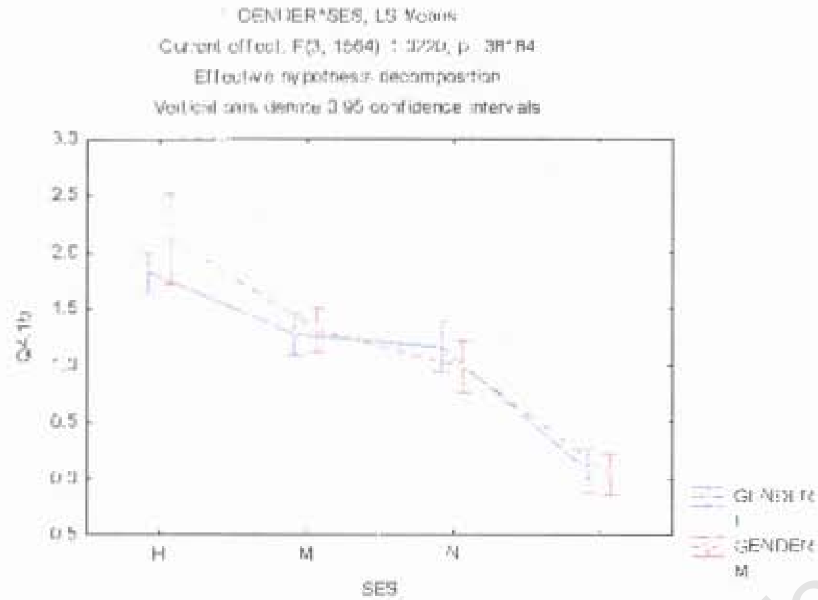
GRAPHICAL COMPARISONS OF THE MALE AND FEMALE SCORES ON CERTAIN ITEMS, GROUPED ACCORDING TO FOUR LEVELS OF SES



GENDER*SES; LS Means
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
Q3.1
SES
H
M
N
L
GENDER
F
GENDER
M

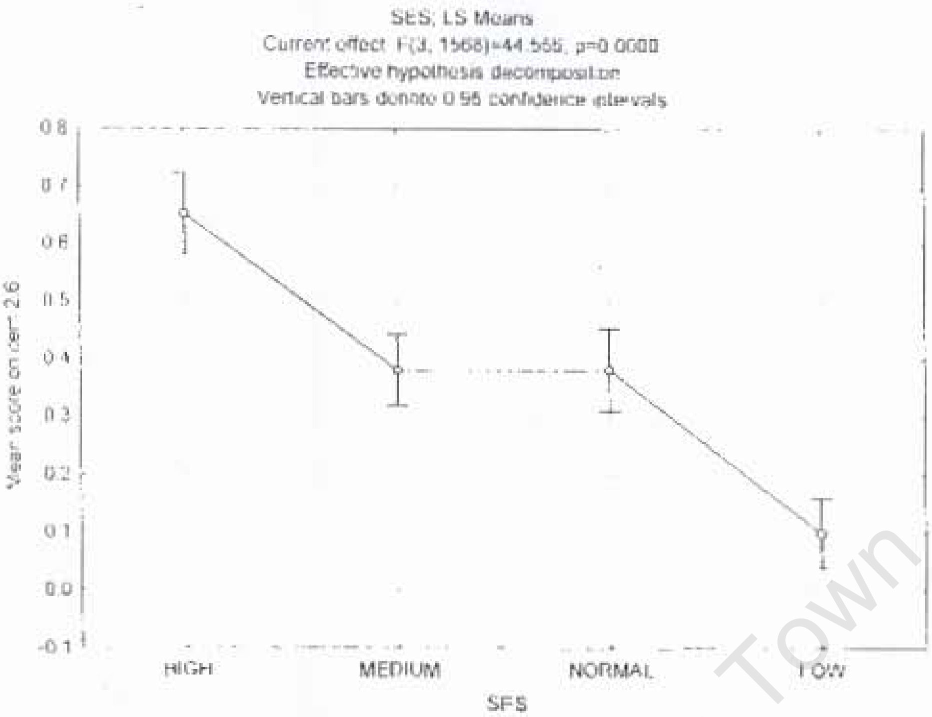


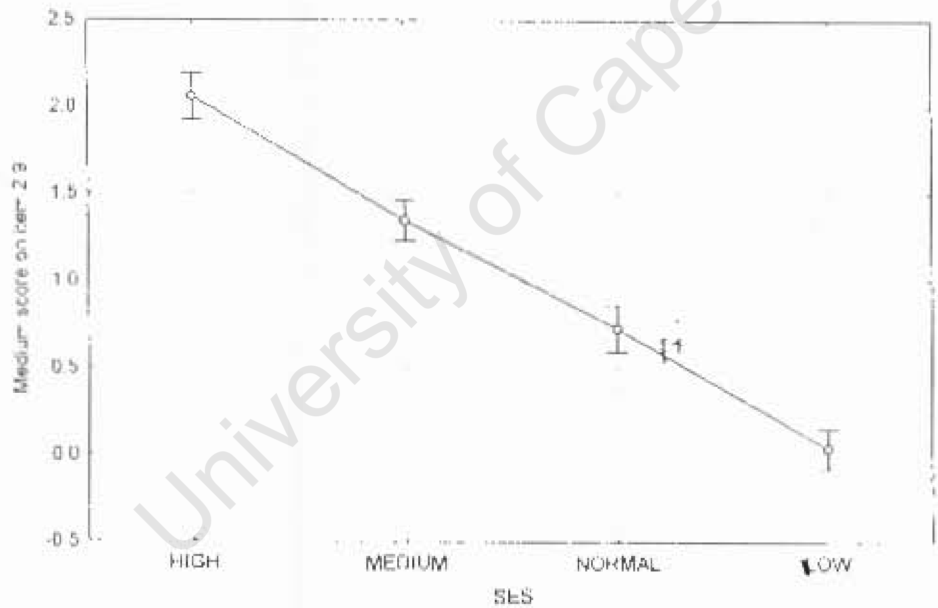
GENDER*SES; LS Means
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
Q2.5
SES
H
M
N
L
GENDER
F
GENDER
M

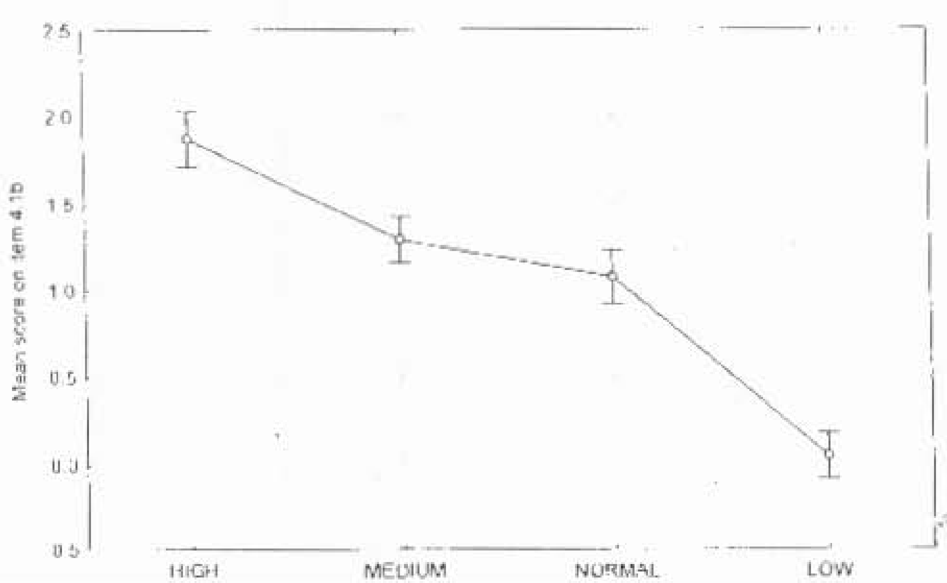

GENDER*SES, LS Means
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
2.5
2.0
1.5
0.5
H
M
N
SES
GENDER
M

APPENDIX 7

GRAPHICAL PRESENTATION OF DIFFERENT SES SCHOOLS


SES; LS Means
Current effect: F(3, 1568)=44.565, p=0.0000
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
HIGH
MEDIUM
NORMAL
LOW
SES


2.5
2.0
1.5
1.0
0.5
0.0
-0.5
HIGH
MEDIUM
NORMAL
LOW
SES


2.5
2.0
1.5
1.0
0.5
0.0
HIGH
MEDIUM
NORMAL
LOW

APPENDIX 8

LETTER FROM THE WCED GIVING THE RESEARCHER PERMISSION TO CONDUCT RESEARCH IN THEIR SCHOOLS

Navrae
Enquiries M F Kleinschmidt
IMibuzo

Telefoon
Telephone 021 659 4305
IFoni

Faks
Fax 021-659 4310
IFeksi

Wes-Kaap Onderwysdepartement

Western Cape Education Department

ISebe leMfundo leNtshona Koloni

Verwysing
Reference Research
ISalathiso

4/13/2005

The Principal

....

PERMISSION TO CONDUCT RESEARCH

Dear Colleague

Mrs Ferial Mullajee has sought permission from my office to conduct research at your school. She is a science Masters's student at UCT. She needs copies of the learners' Natural science answer books (Section B).

We support her request to collect data on condition that it meets with your approval as head of the institution and does not needlessly disrupt the rest of the school.

We wish Mrs Mullajee every success in her studies and trust that her research will benefit all our teachers.

(signed) Mackie Kleinschmidt

(CHIEF CURRICULUM ADVISER
CENTRAL EMDC)
Date: 13 April 2005

APPENDIX 9

LETTER ADDRESSED TO THE PRINCIPALS

Navrae
Enquiries M F Kleinschmidt
Imibuzo

Telefoon
Telephone 021 659 4305
Ifoni

Fakes
Fax 659 4335
Ifeksi

Verwysing
Reference G.Cowan_RPL
Isalathiso

WES-KAAP WESTERN CAPE INTSHONA KOLONI

PROVINSIALE ADMINISTRASIE WES-KAAP
Onderwysdepartement

PROVINCIAL ADMINISTRATION WESTERN CAPE
Education Department

ULAWULO LWEPHONDO LENTSHONA KOLONI
ISebe leMfundo

11 March 2004

The Principal

....

PERMISSION TO CONDUCT RESEARCH

Dear Colleague

Mrs Ferial Mullajee has sought permission from my office to conduct research at your school. She is a science Master's student at U.C.T. She needs to conduct an interview with 6 Grade 10 learners based on the Natural Science CTAs that they wrote last year.

We support her request to conduct these interviews on condition that it meets with your approval as head of the institution and does not needlessly disrupt the rest of the school.

We wish Mrs Mullajee every success and trust that her research will benefit all our teachers and learners.

Mackie Kleinschmidt

Chief Curriculum Advisor (EMDC – Central)

MELD ASSEBLIEF VERWYSINGSNOMMERS IN ALLE KORRESPONDENSIE / PLEASE QUOTE REFERENCE NUMBERS IN ALL CORRESPONDENCE

Private Bag X4
Athlone 7794

7 Main Road
Mowbray 7764

File ref : ferialwoodleth