Focus on Seven

REPORT ON AN INVESTIGATION INTO LANGUAGE-SENSITIVE ACTIVITY-BASED METHODOLOGY IN PRIMARY SCIENCE TEACHING AT THE GRADE 7 LEVEL

March 1998 - October 1998

BY

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October 1998

Commissioned by the President's Education Initiative through the National Department of Education (DoE) Managed by the Joint Education Trust Funded by DANIDA

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EXECUTIVE SUMMARY

1. Background

This report documents Focus on *Seven,* a research study commissioned by the President's Education Initiative (PEI), through the National Department of Education (DoE). The study was conducted in association with the Primary Science Programme (PSP).

2. Purpose and focus of the study

The purpose of the study was to *investigate* and begin to develop explicit indicators of effective practices and pedagogical processes for Grade 7 learners in the Natural Sciences Learning Area. The analytical objectives of the study were to focus on teachers' classroom practices, and growth in *learner* achievement and attitudes towards the Natural Sciences. In particular, the study focused on the relationship between *teachers'* instructional practices and growth in learners' understanding and knowledge of Earth Sciences,- more specifically Earth *features* (including gravitational force), water and rock cycles, Earth in the Universe; and environmental issues such as pollution; and *learners'* ability to:

- understand and process simple and complex information;
- interpret, construct and apply scientific models;
- interpret, organise and *represent* data/information;
- communicate their scientific understandings and knowledge; and
- theorise, analyse and solve problems.

3. The research model

The Third International Mathematics and Science Study (TIMSS), a research study sponsored by the International Association for the Evaluation of Educational Achievement (IEA) provides the *research* model for the study.

4. Research questions for the study

The research questions for Focus on Seven are derived from the four research questions formulated for TIMSS. The adapted research questions for the study are:

1. What is the intended curriculum for Grade 7 Natural Sciences learners in 11 Grade 7 classes in the second term of 1998 (i.e. that which the teachers intend to teach)?
2. What are the variables in the social and educational contexts for learning between the 11 Grade 7 classes (i.e. the learners' home environments and the school environments)?
3. What is the implemented curriculum as is evident in the classroom practices of the Natural Sciences teachers of the Grade 7 classes (i.e. that which teachers actually teach),
4. What is the attained curriculum for each class as manifested in Grade 7 *learner* achievement in science tests designed by TIMSS and matched to the intended curriculum (i.e. that which learners actually learn)? and
5. What are the relationships, if any, between all of these?

Because of the small sample of the pilot study, no conclusive answers to the 5th question are provided, but the study provides valuable pointers to questions to be investigated more fully in follow-up studies.

5. Methodology

The most important data sources for the study were:

- school and teacher survey questionnaires;
- pre-test/post-test items (designed by TIMSS)
- learner questionnaires;
- teacher and school questionnaires;
- lesson observations using an observation schedule, and video recordings of Natural Sciences teaching; and
- structured interviews with teachers

6. Research design

The analytical objectives of the study were the teachers' instructional practices and learner achievement. Thus the focus of the study was on trying to identify effective teaching strategies through an investigation into the relationship between the implemented curriculum and learner achievement at the Grade 7 level. Teachers and learners were the primary units of analysis for the study with schools sites as secondary units of analysis. Using the learners and teachers as the units of analysis was consistent with the goal of providing information about teachers' instructional practices, the performance of learners, and relationships between the two.

The research design included:

- a pre- and post-test design using identical selected items from TIMSS; testing eleven Grade 7 classes in ten schools;
- two observations of eleven Grade 7 Natural Sciences lessons in operation; eleven interviews with the sample of teachers;
- a comparison of the pre- and post-test results of the experimental group; and
- a comparison of the post-test results of the experimental sample with the results of a control group of learners from the larger TIMSS
- a comparison of the post-test results of the experimental group with the eleven teachers' assessment of individual learners in their classes;
- a comparison of the post-test results of a sub-sample of 65 learners from the experimental group with the assessment of the sub-sample through the use of a specially-designed Performance Task; and
- using SPSS to establish relationships between the implemented curriculum, the social and educational context for learning, and learner achievement.

7. Target population

Funding for this research was obtained by the Primary Science Programme (PSP), a non-governmental education organisation that provides in-service education and training to primary school science teachers. A particular focus of the PSP Western Cape region is the role of language in the teaching and learning of science at the upper primary level. Teachers who participate in the PSP's language-sensitive activity-based methodology teacher development workshops generate learning material (activities/tasks) designed to develop learners' language functions and the process skills of science.

Schools that are serviced by the PSP are predominantly schools where:

- physical resources are limited;
- the majority of learners at the schools come from working class and lower middle class socio-economic. backgrounds, and are unlikely to acquire formal knowledge of the Natural Sciences at home;
- learners are expected to learn Natural Sciences in a language other than their own.

Sites

Ten schools with similar social and educational contexts were selected for the study so that the focus on learner achievement and teachers' classroom practices could be maintained. This meant that the social and educational variables at the schools selected by the PSP were fairly insignificant. This made it easier to attribute any differences in learner achievement to differences in the teaching methods used rather than to differences in socio-economic backgrounds.

The main criteria for the selection of the sample of schools for the study was that: a) the schools were generally representative of the majority of traditionally 'black' primary schools in urban areas in South Africa. That is, the conditions of the schools approximated the kinds of conditions that exist in the majority of urban township schools across South Africa; and

b) at least one of the Grade 7 teachers at each school was participating in the PSP's language-sensitive activity-based methodology teacher development programme, and was committed to following the PSP Natural Sciences Learning Programme for the second term.

Teachers

A sample of eleven Grade 7 Natural Sciences teachers has been used. The sample is comprised of one teacher at each of nine schools and two teachers at the tenth school. Five of the teachers are male and six teachers are female. All the teachers reported that they used English and Xhosa as the languages of teaching and learning in their Grade 7 lessons.

Learners

An overall sample of 416 Grade 7 learners has been used for the study. Of the sample, 54% were girls.

In addition sub-samples of the experimental group of learners within the eleven Grade 7 classes were used for the performance assessment tasks (developed by the PSP and administered during the third term of 1998). The sub-sample consisted of 65 learners comprised of two learners in each class whose post-test results were amongst:

1. The highest in the class;
2. The 'middle' of the class; and
3. The lowest in the class.

The *Focus on Seven* researchers negotiated with the HSRC, the body responsible for conducting the Third International Mathematics and Science Study: South Africa (TIMS:SA), around obtaining item test results from the larger TIMSS of a control group whose socio-economic background and educational context closely matched that of the experimental group. These were used to compare the results of the experimental group with the results of the control group.

8. Research findings

The study of the intended curriculum

The initial study of the intended curriculum revealed that

- all eleven teachers held a common intended curriculum. They all intended following the PSP Learning Programme;
- the Learning Programme that all eleven teachers intended following in their Grade 7 Natural Sciences programmes in the second term was guided by learner-centred, activity-based *methods* advocated by the broad principles of OBE; and
- all the teachers intended using the same curriculum material (PSP activities) for their Grade 7 teaching of the Natural Sciences in the second term.

The study of the intended curriculum revealed that the PSP Learning Programme together with its activities played a key role in structuring instruction and providing teachers with a context for achieving the outcomes of the new curriculum.

The study of the social and educational contexts for learning

Data on the social and educational contexts for learning indicated that the sample of schools, teachers and learners formed relatively homogenous groups. However, data also revealed key school and classroom variables_ andlor variables in teacher backgrounds that could have contributed to differences in learner achievement, and that might have been related to teacher effectiveness. In particular variables in school characteristics such as school enrolment; teacher characteristics such as teachers' experience, qualifications and attendance at PSP workshops; and classroom characteristics such as class size; average age; the number of Natural Sciences lessons missed, etc. The study also revealed key variables in learner characteristics such as gender, age, number of books at home, parents' educational levels, etc. The identification of key differences in school, teacher, classroom and learner characteristics meant that the relationship between these variables and variables in improvement in learner achievement could be explored.

The study of the implemented curriculum

The study of the implemented curriculum revealed that:

- the PSP Learning Programme was, in a sense, *the* curriculum that guided the teachers' Natural Sciences teaching. (The Learning Programme used in the study was the first draft of the PSP's attempt at developing the theme The *Planet Earth and Beyond* from the new curriculum); and

- the Learning Programme's activities and curriculum material were the main, and, in most cases, the only resources used by the teachers in their Grade 7 Natural Science lessons.

Data on the extent of coverage of the PSP activities revealed variations in the coverage of the activities (some activities were not covered by all the teachers). Data on teachers' teaching strategies revealed that:

- teachers made use of group/paired work and made use of whole class teaching in most lessons;
- learners themselves did practical,, hands-on work in most lessons, and teachers performed demonstrations in most of the lessons;
- all or most of the learners participated actively in most of the lesson;
- teachers used Xhosa and English in their teaching;
- learners were provided with opportunities to speak, read, write and listen to English in most of the lessons;
- learners used Xhosa or Xhosa with science terminology in English to interact with the teacher or with other learners in most lessons; and
- all the teachers' used PSP's language-sensitive, activity-based, learner-centred methodology in their Natural Sciences teaching.

The analysis of data on teachers' application of a more conceptual and processes-based approach to teaching provided evidence of teachers:

- in 86% of lessons engaging learners in understanding what was required and in establishing a base for achieving the conceptual goals of the lesson;
- in 72% of lessons engaging learners in developing some procedural understandings and process skills;
- in 49.5% of lessons in engaging learners in using their primary language and the language of learning to express their everyday understandings of the science concepts, and in using scientific modes of communication;
- in 72% of lessons in engaging learners with appropriate and correct new/additional discourse, and in focusing on meaning rather than form;
- in 68% of lessons in engaging learners in learner-learner interaction about the science concepts to be learnt in ways that could benefit their thinking/discourse through group work;
- in 58.5% of lessons in engaging learners in using and interpreting the texts/representations provided by giving learners opportunities to `grapple' with them independently of the teacher;
- in 45% of lessons in engaging learners in summative assessments, and in formative assessments through learners' incorrect answers.

The analysis also revealed that in the majority of lessons teacher's did not:

- maintain the focus on the conceptual goals, of the lesson;
- use the activities to ask questions that required learners to ask questions for themselves (hypothesise);
- assist learners to extend and formalise expressions of scientific conceptions into more abstract/ indirect/ symbolic scientific representations / modes of communication;
- assist learners to understand differences between their everyday language] concepts/knowledge and new science language/concepts/knowledge;
- use whole class discussions to assist learners to develop the strategies they needed to work or solve problems collaboratively; Y
- assist learners to develop the strategies they needed to interact with and interpret texts/representations independently;
- use learners' correct answers or insights to elaborate or extend/'push' their thinking further.

So as to ensure that data on the implemented curriculum was amenable to statistical data analysis, teachers' engagement of learners was rated and ranked according to the researchers' overall assessment in terms of all the criteria. This quantitative aspect of the analysis allowed for the relationship between differences and similarities in teachers' instructional practices, and learner attainment in the item tests to be explored.

The analysis revealed much variation in the quality of individual teachers' engagement of learners with the Natural Sciences knowledge (concepts, j processes and language), even when teachers were using the same activities. The analysis revealed that, in spite of the support provided by the PSP, even the best teachers in the sample were constrained in their efforts to engage learners in the Learning Programme and its activities in the way that the new curriculum and the intervention intended, because:

1. disruptions at schools and other interruptions in the teaching programmes made it impossible for teachers
   - to organise their teaching so that they covered all the intended activities; and
   - to develop the theme, *The Planet Earth and Beyond,* coherently as an ongoing narrative/story;

2. teachers struggled to engage learners with Natural Sciences content (concepts and processes) at adequate levels because
   - teachers themselves were under-prepared in the discipline/subject knowledge they were trying to teach, and were therefore not entirely in control of the subject matter; and/or
   - learners lacked both the necessary foundational understandings, processes and language in the Natural Sciences, and other foundational competencies (such as adequate reading levels) to meet the demands of the Learning Programme and the teachers' new teaching approach;

3. the information/guidance that appeared in the PSP activities/texts was insufficient to overcome the effects of the above.

The study of the attained curriculum

The study of the *attained* curriculum revealed evidence overall of growth in science achievement. In particular, the study revealed that:

- no classes showed a decrease in mean achievement between the pre- and post-tests;
- a highly statistically significant overall improvement from the pre-test to the post-test for the whole sample of learners;
- the overall mean difference in improvement across all eleven classes was 5.96%;
- overall 60% of the sample of learners' scores showed positive change in mean achievement in post-/pre-test;
- 10% of the results showed a positive change of an improvement of 21% or more;
- in eight of the eleven classes the improvement between the pre- and post-test was statistically significant;
- the improvement between the pre- and post-test in the two most improved classes was highly significant;
- significant overall improvement was evident for five of the Population 2 items and the one Population 1 item included in the test; and
- the overall post-test results for three items compared favourably with the International averages for the Lower Grade. (However, three classes showed negative improvement between the pre- and post- test for one item, and overall the gain in learner performance for the item was not significant.)

The test items were of a difficulty level that precluded a sensitive analysis of what learners do know and are able to do, nevertheless

- learners' responses indicated that most learners had an understanding of the composition of the Earth;
- although most learners were not able to depict or indicate all three steps in the water cycle, most responses provided evidence of an understanding of precipitation as a 'step' in the water cycle;
- learners' responses in open-ended questions indicated that few learners were able to convert or reformulate their expressions of their scientific understandings/conceptions into more formal abstract scientific models/ representations. Many responses showed little evidence of learners having moved beyond naive realist notions of the concepts/topics;
- it seems that many learners had difficulty in reading and understanding the language and information provided in the TIMSS items and that learners' efforts in the item tests were severely hampered by learners' low reading levels and inadequate second language skills (learners experienced difficulty in decoding and interpreting and answering questions in English);
- learners' incorrect responses to a number of (multiple choice and extended response) items reflected common sense 'everyday' understandings as
- opposed to scientific conceptions, or revealed knowledge and understanding of general concepts (such as pollution) rather than more specialised scientific concepts (such as air pollution, acid rain, the hole in the ozone layer), or

indicated that learners were operating with confused or fragmented understandings of the topics/concepts covered in the Learning Programme (for example, that *'ozone is a solar system'*, and that *'ozone is the force gravity'*);

- learners' responses to extended response items revealed that many learners:

a) were unsure about how to go about answering open-ended questions;
b) had difficulty in expressing their reasoning and thinking in writing;
c) gave vague and imprecise responses lacking in specific information an detail;
d) had not yet learnt to pay careful attention to whether their own written expressions of their thinking and understanding are clear to their 'audiences'.

The study of the attained curriculum also revealed that, in spite of overall gain in learner achievement:

- the overall gain made was relatively modest (5.96%);
- 40% of the learners showed zero or negative improvement;
- the sample of learners still lag behind their international counterparts in the countries that participated in the TIMSS.

A comparison of the results of the sub-sample of 65 learners in the 'hands on' Performance Task with their results in the item test showed a highly significant correlation between learners' scores in the post-test and their results in the PSP Performance Task.

The observations of the PSP programme developers showed that at least two thirds of learners in the sub-sample struggled:

- to read and understand simple instructions and to use and interpret more complex information or texts independently;
- to make and interpret formal scientific models or representations;
- to interpret, organise and use scientific data;
- to support their hypotheses and communicate effectively.

The rank order of the experimental group of learners' overall results or scores in the TIMSS post-tests was compared with the rank order of the marks allocated to individual learners by the sample of teachers. Teachers had used the following general coding rubrics to assess learners' understanding of the concepts to be learnt through each of the activities used in the Learning Programme:

1. The learner understands the concept(s) to be learnt;
2. The learner is be ginning to understand the concept(s) to be learnt; and
3. The learner has no understandings of the concept(s) to be learnt.

The comparison suggested that the teachers who were rated as more proficient by the researchers (in the study of the implemented curriculum) were able to rate their learners' performance quite reliably (whereas the ratings of teachers who were assessed as less proficient were quite unreliable). This indicated that more proficient teachers were able to use their own Natural Sciences knowledge to make better use of the assessment criteria or coding rubrics developed by the

PSP for use by the teachers. It also indicates that the criteria/ rubrics were not adequate for the needs of less proficient teachers, and that coding rubrics for the activities needed to be much more specific for this cohort of teachers.

The percentage of correct and incorrect responses for the five Population 2 items where the most significant improvement was evident for the experimental group was compared with the percentage of correct and incorrect responses for the control groups for the five items. The comparison indicated that the differences were statistically significant for two items. Thus, the analysis indicated that learners from the experimental group did significantly better than their counterparts in the 21 ex-DET schools in only two of the five items. Of all the items that were 'matched' to the intended curriculum, these were the two items that most accurately matched the key content of the activities.

A significant change in learner attitudes at the end of the term was reflected in learners' responses to the questions in the learner questionnaire. At the end of the term

- significantly fewer, learners reported that they believed that lots of natural talent was needed to do well in Natural Sciences, or that they needed to memorise the textbook/notes to do well in Natural Sciences.
- significantly more learners reported that they ought that the application of Natural Sciences can help 'a great deal'. (as opposed to 'not at all) in addressing the problems of air pollution and water pollution.
- significantly fewer learners reported that they thought that Natural Sciences are easy.

However, significantly fewer learners reported that Natural Sciences are important to everyone's life.

The study of the relationship between the attained curriculum, the implemented curriculum, and social and educational contexts for learning and teaching

As already mentioned, the results that emerged from the study of the relationship between the attained curriculum, the social and educational context for learning, and the implemented curriculum need to be treated with caution because of the small sample of schools and teachers used in the study. (For this reason, nonparametric tests were used.) Nevertheless, the findings do suggest trends for further investigation through a larger study using bigger samples of schools, teachers and learners.

No evidence of statistically significant differences between average percentage increases in learner achievement and key variables such as teachers'/learners' ages, teacher/learner attitudes, or the number of minutes of Natural Sciences lessons emerged. However, the study revealed a statistically significant difference between average percentage increases in learners' mean achievement and

- class size, and
- the teachers-ratings in terms of criteria used for the classroom observation schedules.

That is, tests provided evidence of a strong relationship between learner achievement in the item tests, and the researchers' assessment of the extent to which teachers were able to engage learners with Natural Sciences concepts processes and language.

Thus, although the study supported the view that classrooms are subject to many outside influences and contextual variables, the findings indicated that, ultimately, it is the quality of learners' engagement, with Natural Sciences knowledge (content, concepts, processes and language)-that-is- central to learner attainment. Conclusions and recommendations

Data from the investigation into Natural Sciences teaching and learning at the Grade 7 level provided evidence that interventions such as the PSP Learning Programme are making a valuable contribution and have the potential to benefit the school system. The study revealed what an intervention such as the PSP Learning Programme is able to achieve in the context of urban ex-DET schools in South Africa.

However, the conclusions of the Focus on Seven study are that

1. The following act as constraints to teachers emphasising a more conceptual or process-based approach, to teaching:
   - conditions in schools that cut short or interrupt teaching programmes and limit learners `time to learnt';
   - large numbers of learners who lack foundational competencies and skills;
   - limitations in terms of resources such as teaching_ materials and - equipment;
   - limited resources of subject knowledge that teachers them selves have to draw on in meeting the needs of learners spontaneously as they arise; and
   - inadequacies in the classroom material/texts used by teachers in meeting the teaching and learning, and language needs of teachers and learners;

2. Given the existing constraints aid conditions in urban ex-DET schools in South Africa, inputs such as the Learning Programme:

   - cannot alone finally determine what teachers teach and what learners learn;
   - are unable on their own to transform the 'opportunity to learn' that the 'typical' learner in urban township schools in South Africa receives; and
   - are unlikely to impact substantially on the quality of teaching and learning without additional contextual and systemic support.

In other words, the conclusion of the study is that we can no longer afford to ignore the obstacles:

- to teachers in meeting the demands of the new curriculum; and consequently,
- to learners making adequate or substantial learning gains.

Evidence from the study (and others) revealed that `time to learn' is one of the most limited resources in schools of the type studied. The findings suggest that, if the goal of adequate and substantial improvement in learning outcomes is to be achieved, critical contextual and systemic support is required that:

- facilitates and ensures teachers' coverage of key content, concepts and processes; and
- assists INSET interventions/learning programmes to increase their impact.

Suggested strategies for achieving this include developing:

- a curriculum framework that makes all schools and teachers' accountable for ensuring that all learners are provided with the opportunity to at least cover a core of key Natural Sciences knowledge (content, concepts, processes and language);
- incentives for schools to create more effective and supportive teaching and learning conditions, and for teachers to ensure that teaching and learning time, is used more efficiently and purposefully. For example, through rewards for significant improvement in learner performance, and for maintaining high achievement levels;
- graded assessment tasks (exemplars of what learners should be able to do with key content) designed as external and internal mechanisms that would assist schools to establish whether learners are actually performing at appropriate levels.

Thus a recommendation of this study is that official curriculum documents provide information on:

a) the key Natural Sciences knowledge (content and processes) to be covered in, each particular level and/or phase; and
b) acceptable standards of performance for each level and/or phase.

Evidence from the study indicated that teachers are not entirely in control of the Natural Sciences subject matter and that teachers themselves need to master the subject matter they are to teach. The findings suggest that, additional systemic and contextual support in the form of teacher development, that focuses on broadening and deepening teachers' knowledge of subject matter (the content to be covered) is required. This would enable teachers to engage learners with Natural Sciences content more spontaneously and at more appropriate levels.

The findings also support the view that INSET is needed which focuses on assisting teachers:

- with paying much more careful attention to how concepts are presented and developed in the language used in their teaching; and
- to use and employ curriculum material more appropriately and effectively.

Data from the study of the intended, the implemented and the attained curriculum indicates that learning programmes would be more effective and efficient if:

1. They were skilfully designed to provide learning experiences:
   - that are highly focused on„ achieving a few strategic learning goals (rather than trying to provide learners with integrated learning experiences that are inclusive at the-expense of achieving the conceptual goals); and
   - that address content/concepts/`processes/skills/conceptual language (knowledge in terms of increasing cognitive complexity, and that assist learners to use this knowledge in progressively difficult ways.
2. The core Natural Sciences knowledge (contents, concepts, processes, and language including Natural Sciences terms, definitions and vocabulary) to be learnt was made much more explicit (rather than embedded) in the curriculum material.
3. Materials developers paid more careful attention to the kinds and levels of language used in the classroom texts and material provided, in particular, attention to how this language assists or `blocks' second language learners from developing conceptual understanding/language.

The study showed that the PSP-activities played a key role in structuring instruction and that it is essential that such instructional material be very carefully designed and tested.

In particular, the findings indicated that curriculum material would be more effective if it included strategies for

- establishing whether the necessary related foundational language and understandings/conceptions and skills are in place;
- assisting learners to decode and interpret simple and more complex, extended texts/scientific representations;
- moving learners towards a higher level of understanding or thinking through questions formulated both to challenge learners' current thinking and to impel learners to generate questions of their own;
- ensuring that learners are given more immediate feedback on their work; and
- assessing whether learners have really learned what they were meant to learn.

Finally, the Focus on Seven investigation raises some interesting areas for further research. The study indicates a need for more systematic empirical research into what kinds of interventions work best in particular contexts. In particular, research into the kinds of interventions that are most effective in contexts where

- large numbers of learners lack foundational competencies and skills;
- children of working class backgrounds have to learn in a second or third language;
- conditions in schools limit learners 'opportunity to learn' ;
- school resources such as materials and equipment are limited; and
- teachers themselves have limited, resources of subject knowledge to draw on in meeting the needs of the curriculum.

In other words, the study suggests a need for research into what types of interventions can be empirically demonstrated to produce the best outcomes for particular groups of learners, with particular types of teachers, in particular kinds of educational and social contexts. Such research would entail the construction of highly particularised, generic models for Natural Sciences teaching and learning that can be tested in practice.

This research could eventually produce Learning Programmes tailored to meet the needs of learners and teachers with particular knowledge bases and/or experience working in specific contexts. However, such programmes would need to be systematically designed to assist the greatest number of learners in these contexts to attain the best and most desirable results given the time and resources available for teaching and learning.

ACKNOWLEDGEMENTS

The researchers wish to thank the following individuals and organisations:

- President Mandela, the President's Education Initiative and the National Department of Education (DoE) for initiating and sponsoring the research;
- the Danish International Agency (DANIDA) for their financial support;
- the Primary Science Programme for obtaining the funding for the research;
- the members of staff at the Western Cape regional office of the PSP, in particular Charlotte Du Toit, Mascha Ainslie, Rose Thomas, Shane Nzwana and Gcobisi Mbili for their co-operation, assistance, guidance, insights and support;
- the Joint Education Trust (JET), and Penny Vinjevold, for assisting us in the management of the project;
- Dr Hans Wagemaker, Executive Director, International Association for the Evaluation of Educational Achievement (IEA) TIMSS, International Study Centre for granting permission to use the TIMSS instruments;
- Brian Thomson and Michael Martin of the International Study Centre, Boston College for providing us with information about the TIMSS Study;
- the Western Cape Education Department (WCED), in particular Hennie Mentz (Head of Education, Curriculum Services) and Lawrence Manzezulu (Senior subject adviser, Primary Education) for their support;
- Colleen Hughes, Sarah Howie and Elsie Venter of the Human Sciences Research Council for agreeing to supply us with the results of a control group of learners from the larger TIMSS study;
- Prof, Johan Muller, Prof. Douglas Young, and Jean Baxen of the School of Education, University of Cape Town for their co-operation;
- Dr Nick Taylor for his comments and support;
- Prof, Johan Mouton of the Centre for Interdisciplinary Studies, University of Stellenbosch, for providing us with advice on statistical data analysis;
- Hilary Buchanan for her assistance with layout and design;
- Lubabalo Dzedze, Lizo Qangule and Nosizwe Mgudlwa for their assistance with translation and fieldwork;
- Nelius Boschoff for providing us with assistance and advice on statistical data analysis;
- Lynne Slonimsky for her comments on the classroom observation schedules and the performance task; and,
- the teachers, learners and principals who agreed to participate in the study and without whom the study would not have been possible.

The opinions and conclusions presented in this report are those of the researchers, and do not represent the views of the Primary Science Project.

LIST OF ACRONYMS & ABBREVIATIONS

DANIDA	The Danish International Development Agency
DET	Department of Education and Training (prior to 1994)
DoE	Department of Education
HoR	House of Representatives (prior to 1994)
IEA	International Association for the Evaluation of Educational Achievement
Inset	In-service Teacher Education
JET	Joint Education Trust
PEI	President's Education Initiative
Pre-set	Pre-service Teacher Education
PSP	Primary Science Programme
TIMSS	Third International Maths and Science Study
TLRC	Teaching and Learning Resource Centre
UCT	University of Cape Town
WCED	Western Cape Education Department

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1. INTRODUCTION

1.1 Background and Aim

The research for this report was commissioned by the Primary Science Programme. Funding for the research was obtained from President's Education Initiative, through the National Department of Education (DoE).

This report documents Focus on Seven (March - October 1998), an investigation of language-sensitive activity-based methodology in primary Science teaching at Grade 7 level. The investigation was conducted by Focus on Seven in association with the Primary Science Programme (PSP). Focus on Seven is housed in the School of Education, University of Cape Town.

The research model for the study is based on the Third International Maths and Science Study (TIMSS) (1996), a research project sponsored by the International Association for the Evaluation of Educational Achievement (IEA).

In 1994-5 TIMSS measured learner achievement in Science and Mathematics at three levels of the school system in over 40 countries of varying levels of economic development. One of these levels includes the grades at which most learners attain the age of thirteen. (In the South African system, Grade 7 is the Grade in which learners are expected to attain this age). Thus TIMSS provides a model for the research in that it represents international consensus on curricular aims in Science, and provides an array of instruments for measuring Science achievement by learners.

Learner achievement for TIMSS was measured through written tests approved by all participating countries. The tests were developed through a process of international consensus involving extensive input from Science educators and other experts in Science. Included in the written TIMSS tests are items that measure learners' ability to apply their knowledge and skills in non-routine settings.

Underpinning the design of TIMSS is a range of interconnected contextual variables that may contribute to learner achievement. Thus instrumentation includes context (school, teacher and learner) questionnaires designed to elicit information on learner and teacher backgrounds, school and classroom variables, school climate, learners' opportunity to learn, time on task etc. The design allows for collection and comparison of data on variations such as class size; teachers' professional training; teaching experience; age, etc.

In preparation for the research, the Focus on Seven research co-ordinators reviewed a number of TIMSS documents (see References). In addition, the researchers were able to draw from their experiences in Focus on Four (December 1997 - June 1998), a PEI sponsored investigation into Mathematics achievement and teacher effectiveness at the Grade 4 level, which used TIMSS as a model.

The review of TIMSS literature and the *Focus on Four* study revealed that the research design has enormous potential for a study such as *Focus* on Seven where the goal is to study:

a) teachers' use of language-sensitive activity-based methodology to mediate key scientific concepts, processes and language at the Grade 7 level;
b) the Natural Sciences achievement of the Grade 7 learners of these teachers; and
c) to make recommendations as to how improvement in learners' achievement in Natural Sciences at this level might be attained through teachers' instructional practices and use of instructional resources/material.

This report provides:

- the background, aims and objectives of the *Focus on* Seven study including links with the Western Cape Education Department, and other research initiatives in South Africa and overseas;
- a detailed description of the research design and methods, including a description of the sites and samples, and the criteria for selecting the sites and samples;
- a description of the Natural Sciences knowledge and performance requirements of Grade 7 learners as set out in the Primary Science (PSP) learning programme for the second term of 1998;
- a description of the Science knowledge and performance requirements in TIMSS;
- a comparative analysis of the Natural Sciences knowledge and performance requirements set out in Curriculum 2005; the learning programme designed by PSP; and TIMSS;
- the criteria used to measure improvement in the level of learners' achievement in the Natural Sciences Learning Area;
- the instruments developed for assessing learner achievement and teachers' implementation strategies in terms of the criteria;
- an overview of the training of fieldworkers and the testing of the item tests;
- the results of the preliminary investigation of the sites;
- a detailed description of the fieldwork;
- data analysis and interpretation;
- main findings and conclusions; and
- recommendations.

1.2 Purpose, aim and rationale for the study

South Africa is currently involved in a process of major curriculum reform, Curriculum 2005. Underlying this curriculum reform initiative are important shifts in terms of philosophies and attitudes towards knowledge and teaching and learning. In particular, the new Curriculum 2005 proposes specific outcomes that outline the knowledge, skills and attitudes to be evidenced by learners in various Learning Areas. These specific outcomes signal a shift away from traditionally content-based outcomes towards knowledge and skills-based outcomes.

One of the assumptions of Curriculum 2005 is that teachers should change their teaching approach from an approach that focuses on rote learning and factual recall to an approach that emphasises conceptual understanding, skills and values. What is not yet clear is which teaching strategies are effective in relation to the new learning outcomes. While Curriculum 2005 planners advocate forms of learner-centred, activity-based methodologies, there appears to be a lack of secure knowledge as to what constitutes effective learner-centred, activity-based approaches and their appropriate deployment (JET, 1997). There is a need to test the effectiveness of such methodologies in terms of learner achievement.

In the 1980s, the Human Science Research Council's Threshold Project MacDonald, 1990). revealed that teachers' instructional practices together with poor, practices in the writing of textbooks worked against learners achieving adequate cognitive development, particularly in Mathematics and Science. In particular, the research revealed that South African learners who were expected to learn in a language other than their own

- resorted to rote learning content that they did not understand; and
- were not able to achieve "Cognitive/Academic Language Proficiency" (CALP) (Cummins, 1979) in their primary language or in the language of learning[1].

Clearly, if the intended outcomes of Curriculum 2005 are to be achieved, serious attention needs to be given to the role of language in learners' development of key scientific concepts and processes. In particular, there is a need to identify the instructional practices and resources/material that are most effective in terms of mediating key scientific knowledge (processes, concepts and language) to learners, especially to learners who are expected to learn in a language other than their, primary language..

The purpose of Focus on Seven is to investigate attainment of particular outcomes in the Natural Sciences Learning Area by Grade 7 learners, and the teaching practices, pedagogical processes and resource material effective in terms of mediating these learning outcomes.

The investigation takes the form of a micro study of the ways 11 teachers are using a language-sensitive activity-based methodology to teach Natural Sciences to Grade 7, and of the ways in which learners in these classes are learning. The analytical objectives of the study are to focus on teachers' teaching practices and learners' Natural Sciences achievement. The researchers hope to establish causal links between teachers' classroom practices and improvement in learner achievement in item tests, and in learners' attitudes towards Natural Sciences.

Learner achievement is measured in terms of growth in learners' understandings and knowledge of Earth Sciences, more specifically Earth features (including

[1] CALP refers to decontextualised language which is used in more cognitively demanding, school-type tasks as opposed to BICS (Basic Interpersonal Communicative Skills) which refers to context embedded/everyday language.

gravitational force), water and rock cycles, Earth in the Universe; and environmental issues such as pollution; as well as their ability to:

- understand and process simple and complex information;
- interpret, construct and apply scientific models;
- interpret, organise and represent data/information;
- communicate their scientific understandings and knowledge; and
- theorise, analyse and solve problems.

In other words, the aim of the study is to try to identify those teaching practices and pedagogical processes which may be effective in terms of improving the quality of learning outcomes related to the Natural Sciences Learning Areas of Curriculum 2005.

The schools selected for the study are all former DET schools located in established townships near Cape Town. They were selected because they approximate the kinds of conditions that exist in the majority of urban township schools across South Africa. This is not to deny the wide diversity that exists between individual schools within townships, but rather to locate the study firmly within a major sector of the diverse types of schools that exist in the country.

The rationale for focusing the study on Grade 7 is that it is at this level that important shifts are expected to occur in terms of the level of learners' ability to use scientific knowledge, concepts, skills and processes. In particular, learners at this level are expected to be able to begin to use the scientific knowledge and skills developed in the Foundation and Intermediate Phases to conduct scientific investigations and solve problems. For example, significant shifts are expected to occur in learners' ability to:

- understand and use more complex scientific information/texts;
- construct, interpret and apply abstract/indirect/formal scientific models or representations;
- interpret, organise and represent scientific data;
- identify questions to investigate; and
- share information and communicate scientifically.

Thus crucial shifts in the levels of learners' formalisation of scientific knowledge and skills are expected to take place. By implication, the teacher's mediation of particular scientific processes, knowledge, skills and language becomes critical, particularly for learners who may, lack foundational concepts, and who are unlikely to acquire formal scientific knowledge, skills and language at home.

The intention of Focus on Seven is to investigate the pedagogical processes and teaching practices that best facilitate these kinds of outcomes under the conditions existing in the sample of schools, through an analysis of:

- the intended Natural Sciences curriculum for Grade 7 learners, as stated in Curriculum 2005 and in the PSP's learning programme, and as reflected in the curriculum material used by the teachers,

- differences and similarities in learners' social and educational contexts for learning;
- the implemented curriculum as is evident in the eleven Grade 7 teachers' instructional practices; and
- the attained curriculum, as manifested in the Grade 7 learners' achievement in TIMSS item tests matched to the intended curriculum; and
- relationships between all of these.

1.3 The context of the study

In order to put the study into perspective, it is useful to outline the context of the study in terms of the organisations, people and processes involved in setting up the project, such as the:

- intervention that provided the sites for the study, the Primary Science Programme (see 1.3.1)
- research co-ordinators (see 1.3.2);
- fieldworkers (see 1.3.3);
- timing of the research (see 1.3.4);
- organisation and administration of the research (see 1.3.5);
- links formed with the Western Cape Education Department, and other research initiatives in South Africa and overseas (see 1.3.6).

1.3.1 The Primary Science Programme

The Primary Science Programme (PSP), a non-governmental education organisation that provides in-service education and training to primary school Science teachers, obtained the funding for this research. A particular focus of the PSP is the role of language in the teaching and learning of Science. Charlotte Du Toit, National Language Co-ordinator for the PSP, has developed a Framework for developing language awareness in the Natural Sciences Learning Area (see Appendix A). A teacher, development programme based on this framework aims to provide teachers with “insights into not only developing the interpersonal communication skills of learners but also to start, as early as possible, to develop cognitive academic language proficiency." A further aim of the programme is to assist teachers to develop learners' "thinking, talking, reading and writing skills through carefully planned activities" (PSP research proposal, 1997).

Teachers who participate in the PSP's language-sensitive activity-based methodology teacher programme workshops generate

a) learning programme(s), and
b) learning material

together with the PSP facilitators. The learning programme(s) and the activities/ tasks are designed to develop learners' language functions, the process skills of science, and science concepts. PSP's language-sensitive activity-based teaching methodology entails using the activities to develop learners':

- cognitive academic proficiency;
- knowledge and understanding of scientific concepts and the process skills of science;

- interpersonal communication skills; and
- thinking, reading and writing skills.

In January 1998 a group of teachers together with PSP staff developed the curriculum framework of content to be covered in the Learning Programme used for this research. Activities for the Learning Programme were designed by staff at the PSP. Three of the Grade 7 teachers who volunteered for the study attended a subsequent 2 hour workshop where teachers' tested the activities by completing them together.

Four PSP workshops were held specifically for the eleven Grade 7 teachers who volunteered to participate in the research study. Eight of the teachers attended a 2 hour workshop where they received copies of the activities, together with a list of the key concepts and skills to be developed.

A two day workshop (roughly 10 hours) was held during the school holidays before the second term commenced. The workshop included:

- input on language issues;
- sequencing and pacing the activities; and
- testing some of the activities.

On the first day of the second term a box of resource material was delivered to the eleven teachers at their schools. During the second term seven teachers attended a third 3 hour workshop covering assessment. A follow-up meeting held on 2 June was attended by only 3 teachers. Teachers at this workshop explained how they had assessed learners' learning in one of the activities. After this workshop, the PSP staff decided to develop assessment criteria and performance indicators for all the activities. The Learning Programme used for the study was the first draft of the PSP's attempt at developing the theme *Earth* and *Beyond* from the new curriculum.

1.3.2 The researchers

The two senior researchers contracted by the PSP for the Focus on Seven study are Cheryl Reeves and Caroline Long.

Cheryl Reeves has been a high school teacher for ten years. During this time she also worked as a volunteer adult educator for the Adult Learning Project. In 1991 she conducted interviews and prepared the manuscript for the book `The Struggle to Teach' for SACHED Trust's Publishing Project. From 1993 -1997 she co-ordinated the development and evaluation of an in-service diploma for junior primary teachers through distance education for the Primary Education Project. She assessed the impact of two of the Project's courses on teachers' pedagogical understandings and classroom practice. In 1997 she worked as a researcher for the Primary Science Textbook Project at the University of Cape Town. During the first six months of 1998 she worked on Focus on Four, another of the classroom-based research projects funded by the President's Education Initiative. She has a Masters degree from UCT.

Caroline Long has, over a period of 15 years, taught Mathematics at a range of levels from pre-school to matric, in both formal classroom situations and in less formal situations. She has also written and edited textbooks ranging from Grade1 to Grade 9 and written Maths materials for ASECA, a distance learning project. In 1995 she was temporarily employed at the Cape Town College of Education as a lecturer. At the Primary Open Learning Pathways Trust, she was responsible for teaching the Maths component to in-service teachers and for monitoring in-service teacher practice. She completed a Masters in Maths Education in 1995 at the University of Cape Town. From January - June 1998 she worked as a senior researcher for Focus on Four, an investigation into Mathematics achievement and teacher effectiveness at Grade 4 level.

1.3.3 The fieldworkers

The *Focus* on Seven fieldworkers' main tasks were:

- translating the learner questionnaire from English into Xhosa;
- administering the school questionnaire to the school principals and the teacher questionnaire to the Grade 7 class teachers;
- administering the learner tests and questionnaire to Grade 7 learners at 10 schools;
- completing a fieldworker questionnaire after testing each class;
- collecting the completed teacher and school questionnaire after administering the tests;
- marking and recording the test results according to a coding schedule;
- assisting with translations and transcriptions of videos of teachers teaching. Fieldwork has been closely monitored by the research co-ordinators.

Focus on Seven employed three post-graduate students to conduct part-time fieldwork. As the primary language of most learners at the sample schools is Xhosa, the students are all fluent in English and Xhosa.

The three fieldworkers/translators contracted during the course of the study were Lizo Qangule, Lubabalo Dzedze and Nosizwe Mgudlwa.

Lizo Qangule has a B.SocSci. degree from the University of Cape Town. In the first half of 1998 he gained experience as a fieldworker in Focus on Four. His task as fieldworker for Focus on Seven was to assist with the _translation of the learner questionnaire, and administer the school and learner questionnaires and the pre- and post tests. He also assisted with translation of the lessons observed.

Lubabalo Dzedze has a B.A. degree and a Postgraduate Diploma in Library and Information Science from the University of Cape Town. In the first six months of 1998, he worked as a fieldworker for Focus on Four. His task, as fieldworker for Focus on Seven, was to assist with the translation of the learner questionnaire and to administer the questionnaires and some of the pre-test. item tests.

Nosizwe Mgudlwa obtained a B.SocSci. degree from the University of Cape Town in 1996. As a student she worked as a research assistant in the Psychology Department at UCT, a translator and interpreter at the Child Guidance Clinic, and as a tutor in the Faculty of Social Science at UCT, Her task for Focus on Seven was to assist with administering the school, teacher and learner questionnaires and the post- tests. She also assisted with translation of the videos of the lessons observed.

1.3.4 The timing of the research

Data collection took place during the second term of 1998, between 15 April and 23 June.

Administration of learner tests and questionnaires took place between 15 April - 22 April and again between 17 June - 23 June 1998. Tests were administered as early in the second term as possible before learner achievement could be influenced by the Grade 7 teachers' teaching. Identical tests were administered for the second time as near to the end of the second term as was practicable, so that any influences of the implemented curriculum could be measured. The PSP administered a Performance Task on 11 September 1998.

Classroom observation and teacher interviews took place between 4 May - 19 May and again between 2 June - 8 June 1998.

1.3.5 Organisation and administration of the research

Focus on Seven is one of the classroom-based research projects managed by the Joint Education Trust (JET) and funded by the President's Education Initiative. The project is accountable to JET and the National Department of Education. Funding for the research was obtained by the Primary Science Programme. The two senior researchers were contracted by PSP to conduct the research and write the research report.

1.3.6 Links with the Western Cape Education Department and other research initiatives in SA and overseas

Links with the Western Cape Education Department

Approval to conduct the Focus on Seven research in schools in the Western Cape was granted to the Primary Science Programme by the Western Cape Education Department subject to the following conditions:

- the principals, teachers and learners were under no obligation to assist in the investigation;
- the principals, teachers, learners, and schools should not in any way be able to be identified from the results of the investigation;
- all arrangements concerning the investigation should be done by the researchers personally;
- the investigation should not be conducted during the fourth school term;
- the above conditions should be submitted unamended to the school principal where the intended research is to be conducted; and

- a brief summary of the content, findings and recommendations and a copy of the completed report should be provided to the Director: Curriculum Management (Research Section).

Links with other research initiatives in South Africa

In order to establish complementary relationships, to avoid duplication and keep informed about similar research initiatives in the Western Cape and elsewhere, *Focus on* Seven research co-ordinators contacted and/or met the following individuals and organisations:

- Colleen Hughes, Sarah Howie and Isaac Maja who are currently involved in HSRC research linked to TIMSS;
- Professor Douglas Young, Jean Baxen, Dave Gilmour, Ursula Hoadley, Heather Jacklin and Lena Green who are conducting Curriculum 2005 research projects at the School of Education, University of Cape Town; and
- the Teaching and Learning Resource Centre, the National Language Project, the Primary Mathematics Project, and PRAESA who are currently conducting classroom-based research in the Western Cape.

Links with overseas research initiatives

The researchers communicated with the following individuals via email:

- Brian Thomson and Michael Martin of the International Study Centre, Boston College in order to get information about TIMSS, lists of publications, research protocol regarding use of TIMSS instruments, and the names of IEA contacts;
- Hans Wagemaker, Executive Director, the International Association for the Evaluation of Educational Achievement in the Netherlands in order to clarify the protocol around using the released and unreleased TIMSS items tests in the research.

2. FOCUS ON SEVEN RESEARCH MODEL AND QUESTION

2.1 The research model

The research design for Focus on Seven is derived from the TIMSS Curriculum Framework for Science and the TIMSS research model.

2.1.1 TIMSS Curriculum Framework for Science

The TIMSS Curriculum Framework is designed to guide:
- the development of appropriate instrumentation for assessing learner achievement in Science; and
- the analysis of official and/or school curriculum documents, textbooks or other curriculum material.

In particular, the Framework is designed to provide a guide for developing or describing any 'piece' of curriculum e.g. an item test, a section of text from a textbook, a paragraph from a curriculum guide) in terms of three aspects or parameters (Robitaille et al, 1993: 42). These aspects are:
- a content aspect representing the topic or subject matter;
- a performance expectations aspect representing the expected learner performance or the kinds of performances or behaviours that the test item or piece of text (content) might be expected to elicit from the learner;
- a perspectives aspect representing the values underlying tasks, and the development of learners' interest in and attitudes towards Science.

Table 1 below provides the major categories of these three aspects of the TIMSS Science Framework.

TABLE 1: THE THREE ASPECTS AND MAJOR CATEGORIES OF THE SCIENCE FRAMEWORK

CONTENT ASPECT	PERFORMANCE EXPECTATIONS ASPECT	PERSPECTIVE ASPECT
Earth Sciences Life Sciences Physical Sciences Science, technology, mathematics History of Science and technology Environmental issues Nature of Science Science and other disciplines	Understanding Theorising, analysing, solving problems Using tools, routine procedures, and Science processes Investigating the natural world Communicating	Attitudes Careers Participation Increasing interest Safety Habits of mind

IEA TIMSS. 1993:46.

The content aspect of the Science Framework consists of eight categories. The performance expectations aspect consists of five categories including processes of inquiry such as 'investigating' and 'solving problems'. The perspectives aspect consists of six categories. A more detailed list of all the sub-categories within the TIMSS Science Framework categories is included in Appendix B.

2.1.2 TIMSS research design

The research design for TIMSS includes data on curricular content at the:

- system level (the intended curriculum);
- school/classroom level (the implemented curriculum); and
- learner level (attained curriculum).

Curricular content at the system level consists of the intended curriculum or the Science content (subject matter or topics, expected learner performance, and attitudes) as defined at the national or educational system level.[3]

Curricular content at the school or classroom level consists of the *implemented* curriculum or the Science curriculum as interpreted by teachers and made available to learners.[4]

Curricular content at the learner level consists of the *attained* curriculum or the three different levels of content - the concepts, processes, and attitudes towards Science, which learners exhibit.

However, also central to the research design is the role that the curriculum and contextual variables (for example, school system arrangements and learners' home background variables) play in differences in individual learner achievement.

Thus, in addition to data on curriculum content the research design for the study includes data on:

- curricular antecedents or the general societal and educational contexts in which the school system operates at the system level, the school or classroom level (for example, community, school, and teacher characteristics such as teacher qualifications, etc.) and the learner level (for example, learner grade age etc.); and
- curricular contexts or local educational contexts at the system level (for example, institutional arrangements); at the school or classroom level (for example, school and classroom conditions and processes); and at the learner level (for example, learner experience in the educational context).

2.2 Focus on Seven research questions

The research questions for Focus on Seven are derived from four questions formulated for TIMSS as guidelines in designing TIMSS and in developing the instrumentation used. TIMSS questions have been adapted so that they can be related to learner achievement in item tests before and after the sample of teachers have covered a particular `theme', `*Earth and Beyond',* from the Natural Sciences Learning Area with their Grade 7 classes, and to relationships between teachers' classroom practices and learner achievement.

[3] TIMSS collected information about the intended curriculum through an analysis of textbooks, curriculum guides and other curricular materials.

[4] Teachers in TIMSS provided information related to the implemented curriculum by describing their instructional methods and the time spent teaching the Science topics in TIMSS curriculum framework.

The following are the research questions formulated for the Focus on Seven study:

1. What is the intended curriculum for Grade 7 Natural Sciences learners in 11 Grade 7 classes in the second term of 1998 (i.e. that which the teachers intend to teach)?
2. What are the variables in the social and educational contexts for learning in the 11 Grade 7 classes (i.e. the learners' home environments and the school environments)?
3. What is the implemented curriculum as is evident in the classroom practices of the Natural Sciences teachers of the Grade 7 classes (i.e. that which teachers actually teach);
4. What is the attained curriculum for each class as manifested in Grade 7 learner achievement in Science tests designed by TIMSS and matched to the intended curriculum (i.e. that which learners have actually learned)?; and
5. What are the relationships, if any, between all of these?

3. FOCUS ON SEVEN RESEARCH DESIGN

The analytical objectives of the study are to focus on teachers' instructional practices and learner achievement. Thus the focus of the study is on identifying effective teaching strategies through an investigation into the relationship between the implemented curriculum, and learner achievement at the Grade 7 level. Teachers and learners are the primary units of analysis for the study with schools sites as secondary units of analysis. Using the learners and teachers as the units of analysis is consistent with the goal of providing information about teacher's instructional practices and performance of learners, and the relationship between the two.

The design for the research includes:

- a pre- and post-test design using the same selected items from TIMSS;
- testing a sample of eleven Grade 7 classes in ten schools;
- two observations of eleven Grade 7 Natural Sciences lessons in operation;
- eleven interviews with the sample of teachers;
- a comparison of the pre- and post-test results of the experimental group using SPSS (Statistical Package for Social Sciences);
- a comparison of the post-test results of the experimental sample with the results of a control group of similar South African learners from the larger TIMSS study;
- a comparison of the post-test results of the experimental sample with their teachers' assessment of their learning;
- a comparison of the post-test results of sub-samples of the experimental group with the PSP's assessment of the sub-samples using carefully designed performance tasks; and
- using SPSS to establish relationships between the implemented curriculum, the social and educational context for learning, and learner achievement.

3.1. Sites and samples selected for the study

Sites

The researchers in association with the PSP tried to ensure that the social and educational variables at the selected sites were as slight as possible so that any differences in learner achievement could be attributed to differences in the teaching methods used. Thus ten schools with similar social and educational contexts provided sites for the study.

The main criteria for the selection of the sample of schools for the study was that:

1. At least one Grade 7 Natural Sciences teacher at the school was committed to participating in the PSP's Programme;

2. The schools were generally representative of the majority of traditionally `black' primary schools in urban areas in South Africa (the physical resources at the schools are limited, and the majority of learners come from working class and lower middle class socio-economic backgrounds, and are not likely to acquire formal Science knowledge at home);

3. Conditions at the schools were such that formal teaching and, learning is able to take place on a regular basis (the schools have functioning timetables, and a general culture of teaching is prevalent at the schools);

4. The schools were clustered within easy travelling distance for the fieldworkers and researchers and were contactable so that suitable times for visits could be arranged;

5. The primary language of the majority of learners at the schools was Xhosa (The learner questionnaires were translated into Xhosa and the fieldworkers are fluent in English and Xhosa); and

6. Principals and teachers at the schools indicated a willingness to participate in the research.

A survey questionnaire developed to establish the potential teaching and learning time at the schools in the second terms of 1998 was administered to teachers on 3 April 1998 (see Appendix C).

Table 2 below provides information on the potential teaching and learning time for Grade 7 learners as reported by the teachers at the end of the first term 1998.

TABLE 2: TEACHING AND LEARNING TIME AT THE SCHOOLS IN 1998

School	no. periods/ day	length of periods (mins)	no. Grade 7 Natural Science periods/ week*	no. hrs/ average school day	school starting time	school closing time	days which differ	closing time on this/ these day/s	school breaks	extra-mural activities during school time	Grade 7 exam in the second term	Grade 7 exam period second term	approx no of exam days
School 1	11	30	6	6,5	08h00	14h30	Fri	13h00	10h40-11h20	No	Yes	Last two weeks	10
School 2	9	30	5	6	08h00	14h00	Fri	13h00	10h10-10h20 11h50-12h20	Yes	Yes	Last two weeks	6
School 3	10	30	6	6	08h00	14h15	Fri	13h00	10h10-10h20 12h00-12h30	No	Yes	Last two weeks	5
School 4	11	30	6	6,5	08h00	14h30	Wed & Fri	14h00 12h20	10h10-10h20 11h50-12h30	No	Yes	Last two weeks	6
School 5	10	30	5	6	08h10	14h00	Fri	13h00	10h15-10h30 12h00-12h30	Yes	Yes	After June 20	10
School 6	7	45	5	6	08h00	14h00	Fri	13h00	10h10-10h20 11h50-12h30	Yes	Yes	Last two weeks	10
School 7	10	30	6	6	08h00	14h00	Fri	13h00	10h10-10h20 11h50-12h30	Yes	Yes	Last two weeks	.....
School 8	11	30	4	6,5	08h00	14h25	Fri	13h25	10h10-10h30 12h10-12h55	Yes	Yes	Last two weeks	10
School 9	11	35	9	6	07h50	14h00	Fri	13h30	10h00-10h10 12h10-12h30	No	Yes	Last two weeks	5
School 10	10	30	6	6	08h00	14h00	Fri	13h00	10h00-10h10 11h40-12h20	No	Yes	Last two weeks	6-8

...... data not provided
N/A not applicable

* According to some teachers' reports, only half of these lessons were allocated to Natural Sciences. The other half of the lessons were allocated to Biology.

Data from the initial survey on teaching and learning times for Grade 7 learners at the sample schools in 1998 indicated that the average school day at all the schools was comprised of between 6-6,5 hours. Eight of the ten schools reported that they started at 08h00, one at 07h50, and one at 08h10 every day. Six of the schools reported that they closed at 14hOO, two at 14h30, one at 14h15 and one at 14h25 on most days. All of the schools reported that they closed earlier on Fridays. According to the reports extra-mural activities would occasionally take place in the second term during the school day at five of the ten schools.

Seven of the schools in the sample reported that they had timetables that operated on a 5 day cycle. Two schools reported that they have 7 day cycles, and one school reported having a 6 day cycle. School days at four of the schools were divided into 10 instructional periods. Four schools indicated that they have 11 periods per day. One school had 9 periods and one school had 7 periods per day. The length of instructional periods at the schools varied from 30-45 minutes each. According to the initial survey the approximate number of hours of Natural Sciences lessons that Grade 7 learners would have per week was 9 hours at one school, 6 hours at five of the schools, 5 hours at three schools, and 4 hours at one school.

Grade 7 examinations were to be administered in the second term of 1998 at all the schools. Examinations at the schools were to take place during the last 2 weeks of the term over a period of approximately 6 instructional days.

Data from the school questionnaire administered during the second term revealed that the sample of schools formed a relatively homogenous group in that:

- all the schools operated at the primary level only; all the schools were former DET schools;
- none of the schools had double shift/platoon systems;
- the languages of instruction at all the schools were Xhosa and English;
- the primary language of the majority of learners at the schools was Xhosa; and
- all ten schools were situated in townships/settlements near Cape Town. Teachers

A sample of eleven Grade 7 teachers was selected for the study. The sample is comprised of one teacher at each of nine schools and two teachers at the tenth school. Five of the teachers are male and six teachers are female.

The sample of teachers formed a relatively homogenous group in that:

- all the teachers were 'adequately' qualified in terms of the COTEP documentation,
- the primary language of all the teachers was Xhosa;
- all the teachers used English and Xhosa as the languages of learning in their Grade 7 Natural Sciences lessons;

- all the teachers were participating in the PSP's language-sensitive activity based methodology teacher development programme;

- all eleven teachers were committed to following the PSP's Natural Sciences Learning Programme in Grade 7 classes for the second term.

Negotiations with the teachers took place at the end of the first term in 1998. Procedures used for obtaining the co-operation of teachers entailed setting up meetings between the researchers and the teachers at the PSP offices at Uluntu Centre in Guguletu. The research co-ordinators and PSP provided the teachers with background information on the research including:

- the organisations involved in sponsoring and managing the research;
- TIMSS, its significance as a research model, and some of the findings of the international study;
- details regarding approval from the Western Cape Education Department to conduct the research and the specified conditions;
- the Focus on Seven research, its purpose, aims and research design;
- what the schools' and teachers' participation in the investigation would involve; and
- the type of feedback teachers would receive in terms of the research (the final report would be made available to teachers, and PSP would arrange for teachers to view and get feedback on the videos of their teaching).

Participation in the investigation was entirely voluntary, with the teachers themselves deciding whether or not to participate in the PSP programme and the research. The responses of teachers to the research was extremely positive, with all eleven Grade 7 teachers participating in the PSP programme expressing a willingness to make a commitment to participation in the research.

Learners

The experimental group

The population level of learners sampled for the Focus on Seven study is defined in terms of Grade 7[5] and the unit of sampling is intact Grade 7 classes. As a large percentage of learners at former DET schools are reportedly over the expected age for these grades, a grade-based definition rather than an age-based definition is used for the *Focus* on Seven study. However, a grade-based definition does not necessarily mean that all Grade 7 learners have received the same number of years of formal schooling. A large percentage of learners may have repeated classes and others may have dropped out and returned. Thus all Grade 7 learners were tested regardless of their age or the number of years of schooling they may have had.

[5] The second level of learners measured by TIMSS included learners enrolled in the two adjacent Grades that contained the most learners aged thirteen at the time of testing. In the South African system Grades 7 (std 5) and 8 (std 6) are the two Grades in which learners are expected to attain the age of thirteen. The two other levels measured for TIMSS include the grades at which most learners attain the ages of nine, and the grade at which most learners are completing their last year of secondary schooling.

Using intact classes as the unit of sampling yielded a sample of at least 17 learners who wrote both the pre- and post-test in each of the eleven experimental classes (depending on the class size) and an overall sample of 416 Grade 7 learners. This approach enabled the researchers to compare increases in learner achievement among classes based on the average percentage of correct responses to:

- all the written items in the pre-and post tests; and
- individual items/subsets of test items.[6]

In addition sub-samples of the experimental group of learners within the eleven Grade 7 classes were used for the performance assessment tasks (developed by the PSP and administered during the third term of 1998). The sub-sample consisted of 65 learners, or eleven groups of five/six learners from each class. Each group was comprised of (in all but one case) two learners whose post-test results were amongst: .

1. The highest in the class;
2. The `middle' of the class; and
3. The lowest in the class.

The control group

The Focus on Seven research design intended to establish whether significant improvement occurred in the experimental group from a pre-test at the beginning of the second term to the post-test at the end of the second term. Unfortunately, there are disadvantages to this design in that there is no certainty that differences in learner achievement are the result of the implemented curriculum. They may simply be changes that would have taken place anyway., In particular, they may be the result of changes taking place in learners' cognitive development through maturation.

Thus the intention was to supplement this pre- post-test analysis through a comparison of the post-tests results of the experimental group with the results of a control group. However, identifying a suitable control group was a sensitive issue. The researchers decided that the best available option was to try to use a control group comprised of approximately 200 learners who participated in the original larger TIMSS in South Africa. In South Africa, the TIMS item tests had been administered in the second half of the 1994 school year (from September through to November) (Beaton et al, 1996:8). Thus, when the learners in the experimental group wrote the post-tests, they were at a not too dissimilar stage of the Grade 7 year to that of the control group.

[6] In addition to written tests TIMSS also developed a set of carefully-designed performance assessment tasks to be used with random smaller subsamples of learners within classes. These performance tasks are designed so as to allow for the assessment of learners' performance in terms of their conceptual understanding and problem-solving strategies, a mode of assessment congruent with the goals of Curriculum 2005. However, none of the tasks were suitable for use in the study as none of them matched the content aspects of the intended curriculum. Nevertheless, the performance tasks developed by TIMSS presented viable exemplars for developing similar tasks for use in the study (see page 33).

The Focus on Seven researchers negotiated with the HSRC, the body responsible for conducting the Third International Mathematics and Science Study: South Africa (TIMSS:SA), around obtaining item test results of a control group. In particular, the researchers needed the results of a sub-sample of TIMSS:SA Grade 7 learners[7] whose socio-economic background and educational context closely matched that of the experimental group.

Initially the intention was to draw a control group of 200 learners from 5 intact Grade 7 classes. However this was not feasible as all learners who participated in TIMSS did not complete identical items. This was because in the larger TIMSS the 131 test items were clustered and compiled into eight test booklets administered in equal numbers to each of the participating classes. Test items were rotated through the eight booklets so that a representative sample of learners across the whole population would respond to each item. Tests were administered once only across all participating countries, and all participating learners completed only one of the booklets. Thus the numbers of learners to whom individual items were administered varied in the population as a whole and in each class.

This made it impossible to identify a control group of 200 learners from intact classes to whom all of the identical items used in the Focus on Seven study were administered. However, the HSRC was able to provide frequencies on each item over twenty-one urban ex-DET schools in South Africa. This data provided the number of learners who were given the item, the number of missing responses, and the frequencies for learners' responses. Thus, although a total of 909 learners from the twenty-one schools participated in the tests, the number of learners to whom each of the selected items was administered varied from a high of 433 learners (item 131) to a low of 53 Learners (item R4).

Table 3 below provides information on the number of learners in the twenty-one urban ex-DET schools to whom each of the selected TIMSS items was administered, and the number who responded.

[7]The sampling process in the original TIMSS was extremely stringent. Overall the sampling procedures in South Africa for Population 2 did not meet all the criteria. However, fortunately the sample of Grade 7 learners did meet TIMSS criteria, and the sample are considered to be representative of Grade 7 learners in the country (Beaton et al, 1996: Appendix A). Approximately 81% of the overall sample for TIMSS:SA were African (Bateson, 1997: 48).

TABLE 3: NUMBER OF LEARNERS TO WHOM EACH ITEM WAS ADMINISTERED

Item		Number of learners to whom item was administered	Number of learners who responded[8]
B1		436	433
F4		341	336
F5		342	338
H3		330	326
H4		321	315
I17	Earth's water cycle	115	110
J1	Earth's surface	116	116
K17	Position gravity acts	114	110
N5	Causes of acid rain	106	105
O12	Gas greatest amount	106	104
O14	Sun and moon	67	67
P3	Life on another planet	-	
Q11	Daylight and darkness	106	101
R4	Ozone layer	53	53
W1A	River on plain – reason 1	176	176
W1A	River on plain – reason 2	206	204
W2	Rain from another place	199	199
Z2a	Not enough water	110	110

3.2 Data sources for the study

3.2.1 The intended curriculum The intended curriculum in TIMSS is comprised of the learning goals specified at the national or regional level, the school level, and the classroom level. Thus the intended curriculum for Focus on Seven is reflected in

- the official Curriculum 2005 documents;
- the curriculum area/theme selected by the, PSP for the learning programme;
- the topics/subtopics, concepts and skills that the sample teachers intended covering in the second term of 1998; and
- the PSP activities/curricular material teachers intended using in their teaching of the Natural Sciences during the second term.

A detailed description and analysis of the intended curriculum is provided in Section 4 of the Report.

3.2.1.1 Official curriculum documents

The Focus on Seven researchers studied the following official curriculum documents:

- Performance indicators for Natural Sciences: Intermediate Phase
- Senior Phase: Policy Document (September 1997);

[8]The HSRC provided the number of learners who had been administered the item but who had not actually reached the item in their booklets (as opposed to learners who were coded as 'missing' because they reached the items but did not attempt them). For the purposes of this study, only data on the correct and incorrect responses have been used and data on missing responses and items not reached have been ignored.

- Curriculum 2005: specific outcomes, assessment criteria, range statements (April 1997).

3.2.1.2 Other sources of information

In addition to studying available official curriculum documents, the researchers were also able to establish:

- the curriculum area/theme selected by the PSP for the Learning Programme;
- the topics/subtopics that the sample of teachers intended covering in the second term;
- the key concepts and skills that teachers intended teaching in the second term; and
- the PSP activity-based material that teachers intended using in their lessons.

3.2.2 Social and educational contexts

In order to collect data on the social and educational contexts for learning, Focus on Seven fieldworkers administered a school, teacher and learner questionnaire at each school. These three questionnaires were adapted from TIMSS questionnaires designed to collect complementary information on local, community, school and learner contexts. All three of the questionnaires were administered in the second term of 1998.

3.2.2.1 The school questionnaire

The school questionnaire was designed to collect information on enrolment and demographics as well as institutional and instructional arrangement at schools. The principals or deputies or an HoD at each of the sample schools were asked to respond to the questions (see Appendix D).

3.2.2.2 The teacher questionnaire

The teacher questionnaire was designed to collect background information about teachers such as their qualifications, age, gender, years of teaching experience, etc. (see Appendix E). Each of the sample teachers was asked to respond to the questions.

3.2.2.3 The learner questionnaire

TIMSS conceptual model of learner achievement identified the following learner characteristics for consideration:

- background;
- socio-economic status of family;
- cultural capital of family including academic expectations;
- learner attitudes towards Natural Sciences;
- teacher and peer influence in Natural Sciences; and
- time spent on Natural Sciences outside of school.

Thus concepts included in the learner questionnaire were informed by 'psychological theories of individual differences and by motivational and sociological concepts such as family background' (Schmidt et al, 1996:17). So, in addition to collecting data on learner attitudes and self-concept in Natural

Sciences, the learner questionnaire (see Appendix F) also collected descriptive information about learner backgrounds and their home and social environment (for example, whether English is spoken at home, the educational resources at home, the academic expectations of their friends, etc.) The questionnaire was administered to all learners in the eleven classes.

3.2.3 The implemented curriculum

The implemented curriculum according to TIMSS is the opportunity to learn (OTL) that is made available to learners in the classroom.

The model for studying the implemented curriculum used by Focus on Seven was developed by the Survey of Science and Science Opportunities (SMSO). The SMSO was a developmental research study formed by TIMSS in order to develop instruments that could inform cross-national differences in learner attainment in TIMSS.

From 1991 to 1993, the SMSO conducted over 120 classroom observations across six countries (France, Japan, Norway, Spain, Switzerland, and the United States). The study's lesson observations focused on the Mathematics and Science classes of nine and thirteen year-old learners in each country (Schmidt et al, 1996:x).

The SMSO conceptual framework for studying the implemented curriculum is represented in the following diagram:

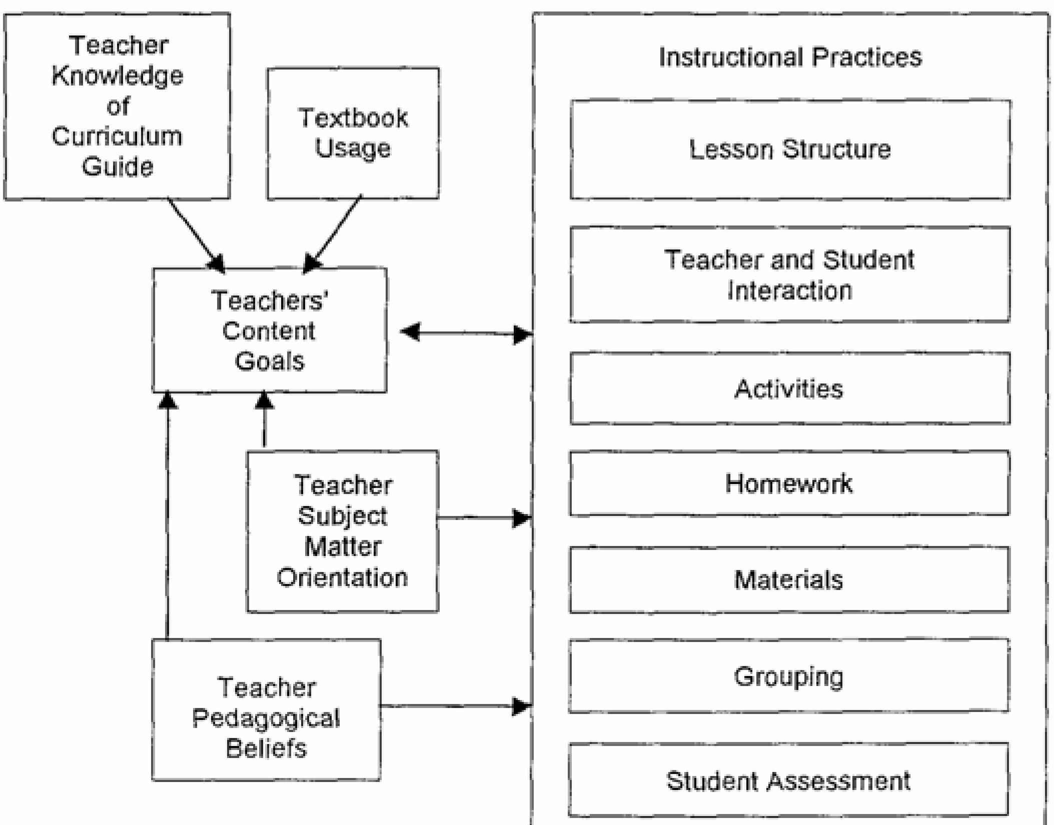


Figure 1: Conceptual Framework: Implemented Curriculum
(Schmidt, W.H. et al., 1996:22)

The implemented curriculum for the *Focus* on Seven study has been operationalised as the opportunity made available to learners to achieve the content and performance expectations tested in the item tests through teachers' classroom practices. This was done through classroom observation (see 3.2.3.1) a teacher interview (see 3.2.3.2), and a teacher questionnaire (see 3.2.3.3).

3.2.3.1 Classroom observation

The Focus on Seven classroom observation schedule (see Appendix G) is designed to collect data on teachers' instructional approaches to teaching the Natural Sciences concepts and processes tested in the item tests. The schedule is comprised of two parts:

Part 1: designed to collect data on the, lesson context and teachers' teaching strategies; and
Part Il: designed to collect data on teachers' engagement with Natural Sciences concepts, processes and language.

Part 1

Part 1 of the observation schedule provides information on
a) the lesson context such as the number of learners present in the class, the classroom conditions; and
b) teachers' pedagogical strategies such as the teacher's use and organisation of support material, use of the language(s) of learning etc.

Part ll

Part ll of the observation schedule provides information on teachers' use of the PSP activities to engage learners with Natural Sciences knowledge (content, concepts, processes and language). The conceptual categories for this instrument are derived from the SMSO conceptual model for instructional practices. The SMSO model includes:

1. the amount of conceptual coherence or focus the teachers build in their lessons;
2. how teachers represent the subject matter; 3. the patterns of classroom discourse;
4. social organisation in the classroom;
5. participation (who participates);
6. the organisation and nature of the instructional tasks;
7. types of evaluation used;
8. the availability and use of technological and other material resources (Martin, 1996a:5.2 & 5.4). [9]

The seven criteria formulated for use in Part 11 of the Focus on Seven classroom observation instrument are derived from the first seven of the above categories (the eighth criterion is covered in Part 1 of the schedule).

[9] The model represents a psycho-social view of classroom practice compatible with contemporary cognitive-psychology literature, and influenced by constructivist education literature in the U.S. (Schmidt et al, 1996: 17)

The criteria provide a conceptual framework for:

- studying teachers' engagement of learners with the Natural Sciences knowledge to be learnt in the PSP Learning Programme; and
- analysing and comparing teachers' classroom practices across twenty-two Grade 7 Natural Sciences lessons.

The Focus of Seven criteria formulated to collect data on the eleven Grade 7 Natural Sciences teachers' practices are:

1. Does the teacher engage learners in achieving the conceptual goals of the activity?
2. Does the teacher use the activity to engage learners in using their conceptual framework to develop some of the procedural understandings and process/ thinking skills they need to think, communicate and work scientifically?
3. Does the teacher use the activity to engage learners in expressing their conceptions (understandings) of the Natural Sciences concepts to be learnt through multiple modes in their primary language and the language of learning?
4. Does the teacher use the activity to engage learners with the new/additional discourse they need to think about, work with, and communicate their understandings of the Natural Sciences concepts to be learnt?
5. Does the teacher use the activity to engage learners in learner-learner interaction about the Natural Sciences concepts to be learnt?
6. Does the teacher engage learners in using and interpreting (making sense of/ decoding) the scientific text(s)/representations provided in the activity?
7. Does the teacher engage learners in the teachers' assessment of whether learners have learnt the Natural Sciences concepts that the activity is designed to teach?

Criteria are based on the assumption that teachers typically make use of certain practices to engage learners with the knowledge (subject matter/ concepts/processes) that they intend to teach in their Natural Sciences lessons (although not all of the practices are likely to be given equal emphasis in all lessons). The criteria are based on the assumption that the practices informing the criteria are recognisable through observation of one or two of each of the sample teacher's lessons, and do not, therefore, require extensive or ongoing monitoring. Thus the research co-ordinators would not be required to rely on teacher self-report through in-depth interviews with teachers as well as classroom observations.

The seven criteria served to make explicit the practices that the research co-ordinators would focus their attention on during the lessons observed. In this way the collection of comparable data across all twelve teachers' lessons was made possible.

Five indicators were formulated for each criterion. The indicators were designed to capture important variations in terms of teachers' practices and use of the PSP activities. Each indicator was formulated and organised on the observation instruments in a way that allowed for significant qualitative differences and/or similarities in teacher's instructional practices in terms of the particular criterion to be categorised and recorded across a graded continuum.

Initially the researchers formulated a general but detailed idea of the indicators for each of the criterion. However, as the lesson observations progressed, the wording used to describe the indicators was slightly modified and/or elaborated. During the detailed analysis of the videos of the lessons further minor refinements were made. This ensured that the instruments were sensitive to and reflected generic similarities and differences across the eleven teachers' practices.

Thus the indicators on the instruments were designed:

- to capture and describe the conceptual quality of teachers' mediation of scientific knowledge (the concepts and the process skills of science); and
- to measure the extent to which individual teacher's mediation enabled learners' conceptual development.

They also provided an indication of the extent to which teachers were using the PSP activities to work with:

- and develop learners' understandings in their primary language (Xhosa) in order to develop proficiency in the language of learning (English);
- both languages in ways that assist learners to develop a conceptual language for the concepts to be learned in their Natural Sciences lessons.

For example, the following five indicators were formulated to collect information on qualitative differences or similarities in teachers' engagement of learners in their assessment of whether learners had learnt the Natural Sciences concepts that the activity is designed to teach.

1. Teacher does not engage learners in his/her assessment of whether learners have learnt the Natural Sciences concepts that the activity is designed to teach.
2. Teacher engages learners in his/her assessment of whether learners have/ have not learnt the Natural Sciences concepts that the activity is designed to teach but mismanages the assessment. For example, by assessing the wrong concepts; by incorrectly assessing the concepts, etc.
3. Teacher engages learners in his/her assessment of whether learners have learnt the Natural Sciences concepts that the activity is designed to teach summatively (i.e. by informing learners that their responses are correct or incorrect). Teacher does not use this information to engage learners in his/her assessment formatively (i.e. to improve learners' learning and the teacher's teaching). For example, by not using learners' answers to identify and assist those learners who have misconceptions, or to provide them with the language that needs to be developed, etc.
4. Teacher engages learners in his/her assessment of whether learners have learnt the Natural Sciences concepts that the activity is designed to teach summatively. Teacher uses learners' incorrect answers to engage them with the teacher's assessment formatively. For example, by using learners' incorrect answers to identify and assist learners who have misconceptions or

to provide them with the language that needs to be developed, etc. Teacher does not use learners' correct answers (i.e. own insights and understandings) to engage learners in elaborating or developing/'pushing' their scientific conceptions and language further.

5. Teacher engages learners in his/her assessment of whether learners have learnt the Natural Sciences concepts that the activity is designed to teach summatively. Teacher uses learners' incorrect and correct answers to engage them with the teacher's assessment formatively. For example, by using incorrect answers to identify and assist learners who have misconceptions, and by using learners' insights and understandings to engage learners in elaborating or developing/'pushing' their scientific conceptions and language further.

The description of each indicator was formulated as unambiguously as possible so that:

- the various indicators were not open to a variety of interpretations;
- appropriate and consistent reports on teachers' classroom practices could be made by different researchers;
- comparison of specific data across the eleven teachers' lessons was possible.

Furthermore, in order to ensure that the data collected were quantifiable and thus amenable to statistical analysis, each indicator for each criterion on the instruments was given a rating or score. This made it possible to summarise each teacher's practices in terms of each of the criteria in a score, and in terms of an overall score for all the criteria combined.

The quantitative and qualitative aspects of the observation instrument were designed to allow for qualitative differences or similarities in teachers' practices in terms of each of the criteria to be related to differences and/or similarities in learner attainment in each of the Grade 7 Science classes.

The two research co-ordinators used the classroom observation instruments to observe each teacher's Natural Sciences lessons through two classroom visits during the second term. Teachers were informed of the proposed dates of these visits. Video recordings and short units of translations of transcripts from the video recordings were made of the first of the two lessons. The recordings and transcripts of the videos of the first lessons and the researchers' notes on the second of the observed lessons have been used for more in-depth analysis of classroom interactions, tasks and forms of assessment.

Thus the primary purpose of the observation schedules was to assess the level at which teachers were able to use the activities to engage learners with Natural Sciences knowledge in terms of the criteria. Secondary purposes of the schedules were to capture the lesson context such as the number of learners in the classroom, and to describe 'outward forms' of teachers' teaching strategies such as the types of classroom organisation used by the teachers.

3.2.3.2 Teacher interviews

After each of the first lesson observations each teacher was asked to respond to a structured interview (see Appendix H). The interview questions on the interview schedule helped to establish details about the lesson context. In particular, the interview included questions about aspects of the lesson that would not necessarily be evident through classroom observations and that could only be obtained directly from the teacher. For example, teachers were asked whether there were any adverse factors affecting the school or learners on the day of the lesson; details about the PSP activity used in the lesson; criteria used for grouping learners, and information about other issues such as other curricular material (besides the PSP activities) used during or to plan the lesson.[10]

3.2.3.3 Teacher questionnaire

In addition to the classroom observation and teacher interview schedules, instrumentation for gathering data on the implemented curriculum included a teacher questionnaire (see Appendix I) administered to teachers at the end of the second term. This teacher questionnaire was linked to the programme of work planned by the PSP for the second term. The purpose of the (end of term) questionnaire was to identify the extent to which the intended curricular topics/subtopics had actually been addressed during the second term. Teachers were asked to:

- indicate whether each of the PSP activities had been covered;
- provide an indication of the estimated number of lessons in which the activities had been covered;
- indicate the number of Natural Sciences lessons that learners had missed in the course of the term and the reasons for the lessons missed.

The researchers will use data from the teacher questionnaire to link the intended curriculum to the implemented and achieved curriculum.

3.2.4 The attained curriculum

The attained curriculum was studied through learners':

a) achievement in TIMSS item tests that reflect the intended curriculum; and
b) aspirations and attitudes towards the Natural Sciences as reflected in their responses in the questionnaire.

3.2.4.1 Selection of TIMSS achievement items which reflect the intended curriculum

TIMSS included a total of 131 written Science test items for the learner population that forms the subjects of the Focus on Seven study (learners in the

[10]The researchers acknowledge that teachers' beliefs and theories about teaching and learning are closely linked to their classroom practices. Nevertheless, the aim of the Focus on Seven study was to investigate effective classroom practices through an examination of the relationship between teachers' classroom practices and learners' achievement and interest in the Natural Sciences. Thus no attempt has been made to use the teacher interviews to establish details about teachers' beliefs or theories about teaching and learning, or to establish links between teachers' beliefs and theories and their classroom practices in terms of each of the criteria.

seventh year of formal schooling)[11]. However, not all of the Science items have been released for general use by researchers. The Focus on Seven researchers decided to select items from the group that are available for general use (see Appendix J) as well as from the unreleased items. Permission to use the unreleased items was obtained from the International Association for the Evaluation of Educational Achievement (IEA) in Amsterdam (see Appendix K).

Selected items from the TIMSS tests 'were used to measure the attained curriculum because

1. they represent international consensus on learner performance at the Grade 7/8 level (grades with largest proportion of 13 year old); and
2. it is easy to administer them effectively and efficiently.

Furthermore, the items assessed formal classroom Science that needed to be mediated to the sample of learners by the teachers as learners were unlikely to acquire this knowledge in everyday contexts.

Two criteria were used to select the TIMSS items used in the Focus on Seven study:

- the item topic (content) and type (multiple choice/free response); and
- the difficulty level of the item in terms of cognitive complexity. Item topic and type

Items had to match the topics (content) that the sample of teachers intended to teach in the second term of 1998 (see Section 4 of this report).

Five content categories were covered in the TIMSS tests that were given to middle-school (population 2) learners: earth sciences, life science, physics, chemistry and environmental issues and the nature of science. About one fourth of the TIMSS items were in open-response format (where learners are required to produce and write their own answers), All the free-response items require extended responses involving multiple steps or synthesis of information where learners show their work.

Eighteen of the TIMSS test items were selected as matching the PSP intended curriculum. Thirteen of the released TIMSS items and five of the unreleased items were selected for the study. Seventeen of the items are from the TIMSS Population 2 item pool. One of the items is from the TIMSS Population 1 item pool.

Seven of the released items (39%) used in the Focus on Seven study are in the free-response format. Three of the extended response items consist of two parts (thus two scores were generated from the responses). The other eleven items

[11] Items covered ten science content areas: Earth Features (11 items); Other Earth Science (10 items); Energy Types (7 items); Light (11 items); Other Physics (20 items), Chemistry 919 items); Environment (5 items); and Other Content (7 items),

(61%) use a multiple-choice format where learners have 4/5 choices, of which only one is the best or correct answer.[12].

Table 4 below illustrates the distribution of the thirteen released (two of the thirteen items consist of two parts) TIMSS test items selected for Focus on Seven across content (topic) areas and performance expectations (see 2.1.1) and item type. Each of the released item tests (including component parts) selected has been coded with one content category and one performance expectation category.

TABLE 4: DISTRIBUTION OF TIMSS ITEMS TESTS SELECTED FOR *FOCUS ON SEVEN* ACROSS CONTENT (TOPIC) AREAS AND PERFORMANCE EXPECTATIONS, AND ITEM TYPE

CONTENT CATEGORY	NUMBER OF ITEMS	NUMBER OF MULTIPLE CHOICE ITEMS	NUMBER OF EXTENDED RESPONSE ITEMS
Earth Science	11	6	5
Physics (gravitational force)	1	1	-
Environmental Issues and the Nature of Science	3	1	2

PERFORMANCE EXPECTATIONS	NUMBER OF ITEMS	NUMBER OF MULTIPLE CHOICE ITEMS	NUMBER OF EXTENDED RESPONSE ITEMS
Understanding Simple Information	5	5	-
Understanding Complex Information	4	2	2
Theorising, Analysing, and Solving Problems	6	-	6

From TIMSS Science Items for Population 1 & 2

The percentage of the released test items used in the study that are devoted to each of the topic areas are:

- Earth Science - 73%
- Physics (gravitational force) - 7%
- Environmental Issues and the Nature of Science - 20%

The main content category `Earth Sciences' includes understanding Earth features, water and rock cycles, and Earth in the Universe. One test item assesses learners' understanding of gravitational force. Three items assess their understanding of environmental issues such as pollution.

The percentage of the released test items devoted to performance expectations are:

- Understanding simple information - 33%;
- Understanding complex information - 27%; and
- Theorising, analysing, and solving problems - 40%.

[12] Whilst this format was unfamiliar to most learners, the researchers anticipated that, as English second language speakers, the sample of learners would find it easier to recognise which of the available options was correct, than they would to create their own answers.

The difficulty level of the item in terms of cognitive complexity

In addition to selecting items that represented the topics to be taught, Focus on Seven researchers also took into account the different levels of difficulty in terms of cognitive complexity of each of the items selected.

Each of TIMSS items is coded according to an International Difficulty Index or an international measure of item difficulty. In addition, the international average percentage of learners who responded correctly to each item in the 2 adjacent (upper and lower) grades tested is provided for each item test. The TIMSS test was conducted at the two adjacent levels, which included the most thirteen year olds. This usually meant the 7th and the 8th grade.

Each item was placed onto the TIMSS international science scale based on learners' performance in both grades. The difficulty index is the point on the scale where learners with that level of proficiency, that is scored at that level on the test as a whole, had a 65 percent probability of getting it right. Thus, the International Difficulty Index is a measure against which the overall results of learners in this study on each of the items can be assessed in terms of the difficulty of the item. The International mean for the upper grade was 516, and for the lower grade 479.

Table 5 below illustrates the distribution of the released TIMSS test items selected for Focus on Seven in terms of TIMSS International Difficulty Index and in terms of the international average percentage of learners who responded correctly to the item in the two adjacent grades.

TABLE 5: ITEM TESTS: INTERNATIONAL DIFFICULTY INDEX AND INTERNATIONAL AVERAGE PERCENTAGE OF LEARNERS WHO RESPONDED CORRECTLY TO THE ITEMS

ITEM NUMBER	INTERNATIONAL AVERAGE PERCENTAGE OF LEARNERS RESPONDING CORRECTLY		INTERNATIONAL DIFFICULTY INDEX
	UPPER GRADE	LOWER GRADE	
I-17	41%	38%	644
J-1	41%	36%	651
K-17	55%	49%	571
N-5	35%	31%	704
Q-11	44%	39%	627
O-4	70%	64%	485
0-12	27%	22%	750
O-14	57%	51%	560
P-3	79%	75%	389
R-4	53%	43%	583
W-1a	79%	76%	383
W-1b	42%	38%	632
W-2	32%	27%	659
W-5	48%	31%	580
Z-2a	43%	37%	598

Table 6 provides a summary of the total number of the selected items for which:

- less than 50% of the international average percentage of learners in the upper/lower grade responded correctly;
- 50% *or* more of the international average percentage of learners in the upper/ lower grade responded correctly.

The Table also provides the number of items coded as less than 500, and 500 or more in terms of the International Difficulty Index.

TABLE 6: TOTAL NUMBER OF ITEMS SELECTED IN TERMS OF THE INTERNATIONAL DIFFICULTY INDEX AND THE INTERNATIONAL AVERAGE PERCENTAGE OF LEARNERS WHO RESPONDED CORRECTLY

UPPER GRADE		LOWER GRADE		INTERNATIONAL DIFFICULTY INDEX	
less than 50%	50% or more	less than 50%	50% or more	less than 500	500 or more
9	6	11	4	3	12

Comparison *of* post-test results with results of Control Group

The post-test results of the experimental sample have been compared to the results of similar South African learners who participated in the larger TIMSS study in 1995. However, the usefulness of the data from the larger TIMSS:SA study was limited as it was not possible to identify a control group of 200 learners from in intact classes to whom all of the identical items used in the Focus on Seven study were administered. Instead, results for each of the Population 2 items used in the Focus on Seven study have been compared individually with the results of twenty one urban ex-DET schools[13].

A Chi-square analysis has been conducted to compare the number of correct and incorrect post-test results of the experimental group in the post-tests and the correct and incorrect test results of the control group.

The analysis of learner attainment includes a comparison of differences between the percentages of correct and incorrect responses for the Population 2 items where the most significant improvement was evident for the experimental group with the percentage of correct and incorrect responses of the control groups for the items.

Performance assessment tasks and teachers' assessment of individual learners In addition to written tests TIMSS developed a set of carefully-designed performance assessment tasks to be used with random smaller sub-samples of learners within classes. These performance tasks are designed to allow for the assessment *of* learners' performance in terms of their conceptual understanding and problem-solving strategies, a mode of assessment congruent with *the* goals of Curriculum 2005. However, none of the TIMSS performance tasks were

[13] The number urban ex-DET schools had to be increased until there were sufficient numbers of learners to enable a comparative analysis to be made for each item.

suitable for use in the Focus on Seven study as none of them matched the content aspects of the intended curriculum.

The PSP decided to develop an appropriate performance assessment task linked to the curriculum goals of their Learning Programme for the second term (see Appendix L). The Performance Task made it possible for the Programme to assess learners' performance in more "hands on" tasks. The Task was administered to sub-samples of 65 learners within the eleven Grade 7 classes during the third term of 1998. A comparison of the results of the sub-sample of learners in the performance tasks with their results in the item test has been included in the analysis of learner attainment.

Data on the eleven teachers' assessment of individual learners have also been included in the analysis. Teachers used the following general coding rubrics to assess learners' understanding of the concepts to be learnt through each of the activities used in the Learning Programme:

1. The learner understands the concept(s) to be learnt;
2. The learner is beginning to understand the concept(s) to be learnt; and
3. The learner has no understandings of the concept(s) to be learnt.

The rank order of the experimental group of learners' overall results/scores in the post-tests has been compared with the rank order of the marks allocated to individual learners by the sample of teachers through the use of the coding rubrics.

3.2.4.2 Attitudes as outcomes or perspectives aspect

A learner questionnaire designed to ascertain details about learner backgrounds and changes in learner attitudes and aspirations in terms of Natural Sciences was adapted from TIMSS (see Appendix F).

Included in the learner questionnaire are subsets of questions designed to establish:

- learners' attitudes towards the Natural Sciences;
- their perceptions about the value of the Natural Sciences;
- how they perceive their own success in the Natural Sciences;
- their beliefs about the abilities necessary to succeed in the Natural Sciences Learning Area.

For example, learners are asked whether they think it is important to:
a) do well in Natural Sciences at school?
b) be good at sports?
c) have time to have fun?

The adapted learner questionnaire was translated into Xhosa and tested in a field test using similar Grade 7 learners to those that were to be used in the study.

In the original TIMMS questionnaire, learners were asked to respond to such questions/statements by indicating whether they 'strongly disagree', `disagree', 'agree', or `strongly agree'. However, the field test revealed that some of these choices were too complex for most learners at the Grade 7 level. Thus some questions had to be modified so that learners could indicate responses of 'yes' or 'no', or 'agree' and 'disagree'.

The modified learner questionnaire was administered to the sample of learners at the beginning of the second term. Fieldworkers read and explained each question to the learners in Xhosa. At the end of the second term learners were asked to complete a second questionnaire (see Appendix M) consisting of a subset of questions repeated from the first questionnaire. The fieldworkers read and explained all the questions to the learners in Xhosa.

Learners' responses to the following questions were used to look for changes in learner interest in and attitude towards the Natural Sciences:

To do well in Natural Sciences at school you need:

Agree/disagree

a) lots of natural talent
b) good luck
c) lots of hard work studying at home
d) to memorise the textbook or notes

Listed below are some of the world's environmental problems. How much do you think the application of Natural Sciences can help in addressing these problems?

Not at all/a great deal

a) air pollution
b) water pollution
c) damage to the ozone layer
d) problems from nuclear power plants

What do you think about Natural Sciences?

Yes/No

a) I enjoy learning Natural Sciences
b) Natural Sciences are boring
c) Natural Sciences are easy subjects
d) Natural Sciences are important to everyone's life
e) I would like a job using Natural Sciences

Learners' responses to the question 'How much do you like/dislike Natural Sciences?' at the end of the second term were used to assess whether learner interest in and attitude towards the Natural Sciences could be linked to improvement in learner achievement in the item tests.

3.2.4.3 Data collection quality control for the item tests and learner questionnaires

Preparation for data collection

Two of the fieldworkers had received training and administered item tests and questionnaires in the earlier Focus on Four study. Nevertheless, both fieldworkers received further training for Focus on Seven at a one day orientation course on 13 April 1998. A second orientation was held prior to administering the post-tests on 15 June 1998. Training included:

- an introduction to Focus on *Seven,* its background, aims, purpose and rationale;
- the influence of TIMSS;
- an overview of the fieldworkers' roles, responsibilities and tasks;
- instructions for translations of learner questionnaires;
- instructions for schools visits and administering the item tests and learner questionnaire;
- instructions on returning the tests to Focus *on* Seven

Training sessions on recording the test results was held at the end of April after the pre-tests had been administered and at the end of June after the post-tests had been administered.

Monitoring the quality of the translations of the learner questionnaires into Xhosa

At the beginning of April fieldworkers translated the learner questionnaire into Xhosa. Fieldworkers are fluent in English and Xhosa. Their brief was to:
- find equivalent words and phrases to those used in the original questionnaire;
- ensure that the reading level of the questionnaire remained the same in the Xhosa version as in the English version; and
- ensure that the essential meaning of the questions did not change. The final version was then reviewed by both fieldworkers.

Field Tests

The fieldworkers tested the item tests and the learner questionnaire in a field test in the last week of the first term in 1998. The field test was conducted using Grade 7 learners from a school site similar to the schools that were used in the study. Learners' results in the field test of the item tests were low. This was hardly surprising given that the Science achievement in South Africa at the Population 2 level in the TIMSS was very low in comparison to the achievement of learners of the same age in other countries that participated.

However, in the absence of alternative valid tests, the researchers decided to go ahead and use the unmodified TIMSS tests because:
a) they represent Scientific knowledge and processes that have been externally validated as representing an appropriate standard at the Grade 7 level; and
b) learners who participated in the larger TIMSS Study were to be used as a control group and their results on TIMSS items would be compared with the post-test results of the experimental sample.

Thus, although some adjustment in terms of testing time (see section headed testing time for details) were made, the tests needed to be identical to those administered to the TIMSS control group and could thus not be modified. Only 21% of learners in TIMSS South Africa wrote the item tests in their home language, and the majority of learners wrote the TIMSS tests in a language other than their primary language (English/Afrikaans). (Howie, 1997:11). Thus the items used for the Focus on Seven study were not translated and administered in Xhosa.

Data collection procedures for test items

Although the PSP programme developers were aware of the specific items selected for the study, it was imperative that the item tests remained confidential. In particular the researchers stressed that schools must not have access to the tests as this would contaminate the data.

Uniformity of test administration so that comparable data on learner attainment were collected at each site was crucial. The following standardised data collection procedures for administering the learner tests were adopted (see Appendix N):

The fieldworker was to:
- establish the names of learners in the class who were absent on the day of the tests;
- ensure that copying did not occur. For example, by asking learners to sit as far away from one another as is possible or, if this is not possible to put their suitcases or bookbags between them on the desks;
- not give teachers copies of the tests and ask them not to stay in the class while the learners were being tested;
- provide each learner in the classes with a pencil supplied by Focus on Seven;
- explain to the learners that they should not talk to each other or look at their classmates work. They should not use calculators, rulers or erasers (they can cross out errors) (Fieldworkers used the learners' primary language to explain this);
- hand out the tests one at a time and tell the learners to complete the details on the cover sheet but not open the test booklets until they are told to do so;
- use the examples provided to explain to learners what is meant by multiple choice questions and how they were different from short-answer or free-response questions;

- explain to the learners that the test questions were written in English;
- tell the learners that they should do all their work on the actual test pages;
- tell the learners how much time they have for the test items;
- encourage the learners to do the best they can but not help them in any way through giving them guidance of any sort;
- encourage learners to attempt every item;
- not include learners who arrive after the testing has begun, but allow them do the test;
- take in the test booklets if learners have to leave the room during the test (e.g. to go to the toilet), and indicate this on the front cover of the particular booklet;
- check that the number of completed test booklets tallied with the number of learners in the class before they left the testing room; and
- ensure that all item test booklets including blank booklets were secured.

Furthermore, in case the format of the item tests was unfamiliar to most learners, fieldworkers were instructed to take care in introducing and explaining the difference between the multiple-choice format and the free-response format.

In addition to the above, fieldworkers were required to complete a fieldworker questionnaire (adapted from TIMSS) after each testing session (see Appendix O). The questionnaire asked them to provide background information on data collection procedures for each testing session. Included in the questionnaire was information about events outside the study's control that may have affected testing. Thus the questionnaire includes questions about adverse factors or events affecting the school or learners on the day of the testing; whether there was adequate seating space for learners to work on the tests without distractions; whether any deviations from the prescribed timing had to made, etc.

Testing time

TIMSS provides the following estimates of the amount of time needed by the population of learners used in the study to complete each item type:

TABLE 7: TIME NEEDED TO COMPLETE EACH ITEM TYPE (TIMSS)

MULTIPLE CHOICE	EXTENDED–RESPONSE
1 minute	3 minutes

Of the 18 items selected for the Focus on Seven study, eleven are multiple choice items. Seven items require learners to provide their own answers, in other words they require an extended-response. One of these items consists of a part A and a part B. Thus, according to TIMSS, the estimated total time allocated for the item tests selected was 35 minutes.

In order to establish the amount of time needed for the particular population of learners used in the study to at least attempt each item type, the instruments were tested in a field test with a class of similar Grade 7 subjects. The field test revealed that adjustments to the time allocated for the items needed to be made as learners experienced difficulty with the unfamiliar format of the item tests and, in some cases, lacked the reading skills necessary to read the questions quickly. The researchers decided to allocate 45 minutes for the test so as to ensure that all learners would have the opportunity to at least attempt each question.

The timing of the tests

Most of the schools were provided with a provisional timetable of the testing times at the end of the first term. The exact dates of the pre-test administration were confirmed once schools re-opened for the second term. The necessary logistical arrangements were made with individual schools during the first week of the second term in 1998. The pre-tests were administered as planned between 15 April and 22 April.

The post-tests were administered at the end of the second term between 17 June - 23 June 1998. Fieldworkers reported low learner attendance at some of the schools. This was largely because:

- uncertainty about the possibility of teacher mass action caused schools to commence examinations earlier than originally planned. As a result, learners had finished the end of term examinations before the fieldworkers were able to administer the post-tests. There was low learner attendance after the examination at some schools, in particular at School 6; and
- tests at some schools had been organised on 24 June (3 days before the end of the term). However, a change in the closing-date of schools for the second term was announced shortly before the term ended. This meant that schools closed on Wednesday 24 June instead of Friday 26 June. As a result, three classes (Schools 3, 4 and 9) had to be tested on the last day of school. Learner attendance at School 4 was particularly poor.

Table 8 provides information on the number of learners in each class, the number of learners in each class who wrote both the pre- and post-tests, and the date of the post-tests.

TABLE 8: LEARNERS IN EACH CLASS WHO WROTE PRE- AND POST-TESTS AND DATES OF POST-TESTS

TEACHER	CLASS SIZE	NO. OF LEARNERS WHO WROTE POST- AND PRE-TESTS	DATE OF POST-TEST
1	32	31	19/6/98
2	48	47	17/6.98
3	40	32	24/6/98
4	32	17	24/6/98
5	47	43	18/6/98
6	67	36	22/6/98
7	31	23	22/6/98
8	37	25	19/6/98
9	49	40	24/6/98
10	72	63	19/6/98
11	68	58	19/6/98

The PSP's performance tasks were administered on 11 September 1998 at the Uluntu Centre, Guguletu.

Scoring of test items

The test items used for the Focus on Seven study include multiple-choice and free-response formats. Learners scored one point for each correct answer in the multiple-choice items. Multiple choice items were useful in that an analysis of the items could be to identify aspects of teaching that were weak. Furthermore, incorrect choices by the majority of learners could be used to identify common misconceptions. However, although multiple choice test items provided information on content outcomes, they did not provide much information about the procedures learners used to solve problems. The free-response items were designed ¯to reveal some of these procedures as well as learners' reasoning processes and understandings.

TIMSS open-response items were scored using a two digit coding rubric. The two digit score provided a score for the `correctness' of the response and an indication of the type of response through a diagnosis of different responses with the same scores. The TIMSS coding rubrics measured three aspects of responses. These were:

- `correctness' (correct, partly correct, or incorrect);
- method or type of explanation or example given; and
- misconception or error type.

The first digit of TIMSS two-digit code represents the 'correctness' of the response. The second digit in the code represents the type of response in terms of explanation or error (for example, specific common errors, common misconceptions) (Martin, 1996a:7-13).

Table 9 provides a generic example of the coding scheme for a free-response item worth one point.

TABLE 9: FREE-RESPONSE ITEMS - CODING SCHEME

CODE	TEXT
10	**correct** response, answer category/method #1
11	**correct** response, answer category/method # 2
12	**correct** response, answer category/method # 3
19	**correct** response, some other method used
70	**incorrect** response, common misconceptions/error #1
71	**incorrect** response, common misconceptions/error #2
76	**incorrect** response, information in stem repeated
79	**incorrect** response, some other error made
90	crossed out/erased, illegible, or impossible to interpret
99	Blank

(From Table 7.2 TIMSS Two-Digit Coding Scheme Martin, 1996a: 7- 77)

Responses coded 10, 11, 12 or 19 are correct and each score one point. Responses coded 70, 71, 76 or 79 are incorrect and score no points. Responses coded 90 and 99 indicate that learners attempted the item but did not provide an answer, or that learners did not make any attempt to answer. These responses also score no points.

The TIMSS coding rubrics assisted the Focus on Seven researchers to analyse learners' responses in ways that provided information about the procedures used by the sample of Grade 7 learners to solve Scientific problems.

3.2.5 The relationship between the attained curriculum, the implemented curriculum and the social and educational context for learning

The relationship between the attained curriculum, the implemented curriculum, and the social and educational context for learning has been analysed through the use of a statistical programme. Data from the database were entered on a spreadsheet format using Microsoft Excel. This data were merged and converted to SPSS format to create an SPSS systems file for analysis. Data-editing procedures were run to check the quality of the data and to check that the conversion to SPSS was accurate.

Data have been analysed in ways that make it possible to identify key variables that could have contributed to differences in the mean improvement in learner achievement in the pre- and post- tests. In particular, data were analysed in ways that related increases in learner achievement in the item tests to variables in the implemented curriculum, and the educational context for ,learning. For example, through a non-parametric analysis (Kruskal-Wallis test) to test whether the pre-post test change in each class measured in the study of the attained curriculum differed. significantly according to, the, number of PSP activities covered in the implemented curriculum.

4. STUDYING THE INTENDED CURRICULUM

The intended curriculum in TIMSS is comprised of the learning goals specified at the national or provincial level, the school level, and the classroom level.

4.1 Description of the intended curriculum

The following description of the intended curriculum includes information on

- the official curriculum documents that the PSP used to guide the Grade 7 Natural Sciences Learning Programme for the second term of 1998 (see 4.1.1);
- the curriculum theme/area covered by the Learning Programme (see 4.1.2);
- the curriculum topics or content teachers intended covering in their Grade 7 Natural Sciences Learning Programme in the second term of 1998 (see 4.1.3);
- the key concepts and skills teachers intended teaching (see 4.1.4);
- the curricular material/activities teachers planned to use for their Grade 7 Natural Sciences teaching (see 4.1.5);
- the assessment criteria and performance indicators that teachers used for the activities (see 4.1.6).

4.1.1 Official curriculum documents used to guide the Grade 7 Natural Sciences Learning Programme in the second term of 1998

All the teachers intended following the Learning Programme developed by the PSP in collaboration with teachers. The Learning Programme was guided by Curriculum 2005 documents on the Intermediate Phase of the Natural Science Learning Area (see List of Sources).

4.1.2 Curriculum theme/area covered by the Learning Programme

Curriculum 2005 documents reveal that the Natural Sciences Learning Area has been organised around four themes, 'The *Planet Earth and Beyond', `Life and Living', 'Energy and Change'* and *`Matter and Materials'.* These themes apply to all grades. The PSP Learning Programme covered aspects of the theme *`The Planet Earth and Beyond'.*

The following is the scope statement for this theme as outlined in the official Curriculum 2005 documents for the Natural Sciences Learning Area:

‘Earth's structure, dynamic features and components - from core to upper atmosphere - and the delicacy of the many environments associated with the Earth must be appreciated and understood at an appropriate level. A grasp of planet Earth's place in the universe can instil a sense of wonder and stimulate the imaginations of learners. Within this theme, learning contexts should be drawn from *under the Earth's surface on the Earth's surface; above the Earth's surface; and beyond the Earth `(*Curriculum 2005, April 1997:134).

4.1.3 The curriculum topics or content that teachers intended covering in their Learning Programme in the second term

Official documentation on Curriculum *2005 does* not provide generic or specific terms for describing the content/topics learners are expected to learn in each theme. Thus the researchers used the TIMSS Curriculum Framework for Science to provide an indication of the generic topics or content teachers intended covering in their Grade 7 Natural Sciences Learning Programme in the second term of 1998. Table 10 that follows provides an indication of the generic topics/subtopics or content teachers intended covering. The Table also provides a rough estimate of the number of lessons that the teachers and PSP expected that the topics/content would take to be covered.

TABLE 10: INTENDED CURRICULUM TOPICS/CONTENT

TOPICS/SUBTOPICS	ESTIMATED NUMBER OF LESSONS
Earth features	29
Gravitational force	3
Environmental issues	3
TOTAL	35

4.1.4 The key concepts and skills teachers intended to teach in the second term

This section provides information about the knowledge and skills that learners were expected to master in the Natural Sciences Learning Programme for the second term. According to the PSP the key concepts teachers intended to teach were:

- Earth is round;
- Earth is made up of concentric layers;
- All matter and energy in the known Universe originated from a huge explosion;
- The sun and its family of planets form an organised system;
- Planets move in fixed orbits around the sun;
- Different planets have different characteristics;
- Rotation (on own axis) and revolution (around the sun);
- Position of land, water, air and amount of each;
- The biosphere is where living organisms occur and interact with air, water, soil;
- Up is away from the centre, down is towards the centre, gravity pulls things to the centre;
- Atmosphere consists of different layers that have different functions;
- Ozone can be destroyed by mankind;
- Rockets are propelled by gases being ejected out the back;
- To leave the Earth you have to overcome the force of gravity;
- You have to take oxygen with you to outer space to burn rocket fuel and to breathe;
- Looking at Earth from a distance and interpreting features;
- Continental drift happened over a long time span,
- The Earth's crust is still changing;
- Water cycles between the crust and the atmosphere;
- Rocks undergo weathering;
- Fragments of rocks are dispersed;
- Topsoil is made of three kinds of particles and humus;

- The different particles settle at different rates;
- Earth is fragile/precious and can be harmed.

The key skills teachers intended teaching learners in the second terms in the Learning Programme were:

- Reading;
- Reading data tables;
- Manipulating/Making models;
- Describing
- Finding patterns;
- Identifying relationships;
- Drawing;
- Imaging;
- Labelling;
- Writing;
- Discussing;
- Matching;
- Comparing;
- Hypothesising; •
- Raising questions;
- Showing relationships and/or patterns;
- Predicting;
- Sequencing;
- Devising and planning investigations;
- Interpreting;
- Planning;
- Synthesising;
- Making conclusions;
- Proving; and
- ' Doing a dance correctly'.

4.1.5 The curricular material/activities teachers planned to use in the second term

The researchers were able to study the learning material/activities that the PSP had developed in collaboration with the sample of teachers. Copies of the activities are provided in Appendix P. An indication of the estimated number of (30 minute) lessons that the PSP and the teachers anticipated it would take to cover each of the activities (see Table 9) was also provided.

Initially the intention was for teachers to use fourteen of the developed activities in the second term. It was estimated that teachers would take a total of 35/36 lessons to cover all fourteen activities. There were at least eight weeks of schooling between the pre- and post-tests at the schools (excluding a 2 week examination period at the end of the term). Learners would thus need to have a minimum of four and half (30 minute) lessons per week if they were to cover all fourteen topics. According to the preliminary survey of teaching and learning times at the schools this was feasible at all the schools with the exception of School 8 where learners reportedly received only 4 (30 minute) science lessons per week.

4.1.6 Assessment criteria for the activities

Assessment criteria were developed by the PSP in collaboration with the teachers. The criteria were developed to assist teachers to assess learning outcomes and/or emerging outcomes in terms of the concept/s to be learnt through teachers' use of the activities. The following three general coding rubrics were developed for the criteria:
1. The learner understands the concepts to be learnt;
2. The learner is beginning to understand the concepts to be learnt; and
3. The learner has no understandings of the concept/s to be learnt .

More specific performance indicators related to the concepts to be learnt through teachers' use of the activities are provided in Appendix Q. The indicators relate to the performance indicators for Specific Outcome 2 from Curriculum 2005 documents on the Learning Area of the Natural Sciences, namely
- *'Acquired scientific knowledge and principles are used to inform actions'; and*
- *'Use acquired knowledge of concepts, principles, basic laws and formulae by discussion, applying, reporting when conducting scientific investigations and other science related work.'*

4.2 Analysis of the intended curriculum

The TIMSS curriculum framework provides a useful model for an empirical analysis of curriculum documents/material. The TIMSS model characterises any. 'piece' of curriculum (for example a test item, a piece of text from a textbook) in terms of three parameters (Robitaille, et al, 1993:42), namely:
- subject matter content (topic area);
- performance expectations (expected learner performance or the kinds of performances or behaviours that the test item or piece of text might be expected to elicit from the learner); and
- perspectives, values or attitudes (underlying tasks).

The analysis of the intended curriculum that follows uses the TIMSS model for analysing curriculum documents/material to provide the key:
1. concepts and skills,
2. learning outcomes,
3. Science knowledge (content) and performance requirements

of the intended curriculum as set out in the Learning Programme and curriculum materials that the sample of teachers intended using in their Grade 7 Natural Sciences lessons in the second term of 1998 matched to

- the specific outcomes and assessment criteria for the Intermediate Phase: Natural Science Learning Area of Curriculum 2005 documents; and

- the TIMSS Curriculum Framework for Science.

The TIMSS Curriculum Framework for Science has been used in the analysis of the intended curriculum because:

a) it was used for developing the TIMSS item tests used in the Focus on Seven study, and

b) it provides

- generic categories and terms for describing 1) the content learners were expected to learn; 2) what learners were expected to do with the content they were expected to learn; and 3) the orientation/values underpinning the content; as well as
- sub-categories of increasing specificity for key content categories, performance expectations categories and perspectives categories. (For example, in the Science framework, the content aspect consists of eight main categories each with 2 - 6 sub-categories).

Figure 2 below, illustrates the main content category, Earth Sciences, with some of its sub-categories.

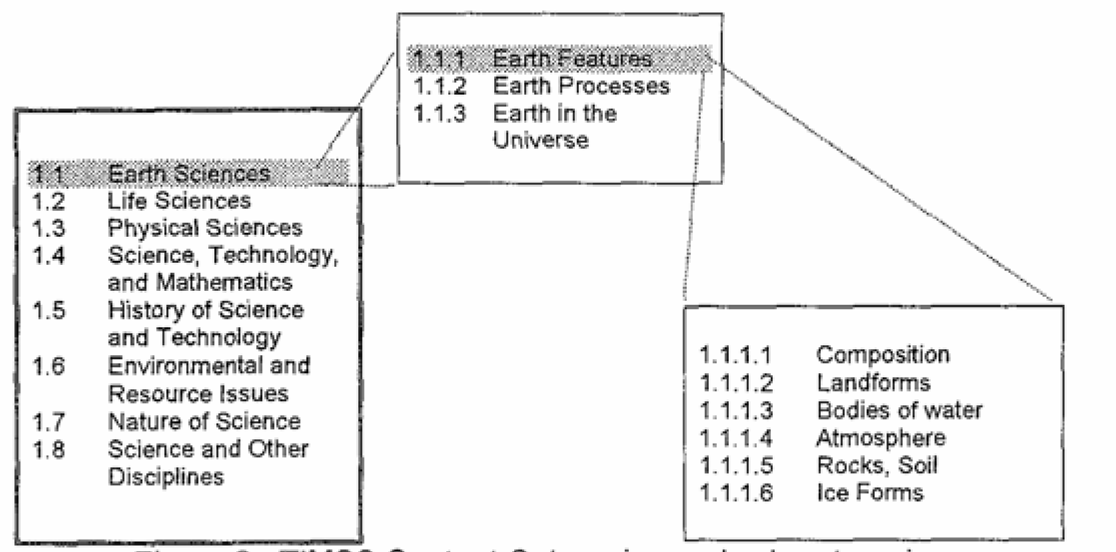


Figure 2: TIMSS Content Categories and sub-categories

(Figure A.1Schmidt et al, 1997b:129)

Appendix R provides a detailed analysis of the key concepts and skills, outcomes/processes, Science knowledge and performance requirements of the intended curriculum. The analysis is based on the PSP Learning Programme and its activities; Curriculum 2005 documents; and TIMSS Curriculum Framework for Science.

The analysis of the intended curriculum provided in Appendix R reveals that the specific outcomes/processes for Curriculum 2005's Natural Sciences Learning Area emphasised in the intended curriculum (the PSP Learning Programme) are:

SO 5 = `*Use scientific knowledge and skills to support responsible decision making*'

SO 2= `*Demonstrate an understanding of concepts and principles and acquired knowledge in* the *Natural* Sciences'

SO 1 = *'Use process skills to investigate phenomena related to the Natural Sciences';*

SO 3= *'Apply scientific knowledge and skills to problems in innovative ways'.*

The analysis also reveals that essential elements of TIMSS Curriculum Framework for Science are covered in the PSP's (intended) curriculum material. In particular the analysis reveals that:

- the following TIMSS content aspects (topics/subtopics) are covered
  - Earth features (1.1.1)
  - Composition of Earth
  - Landforms (1.1.1.2)
  - Bodies of water (1.1.1.3)
  - Atmosphere (1.1.1.4)
  - Soil (types, formation) (1.1.1.5)
  - Physical cycles (water & rock cycle) (1.1.2.2)
  - Building and breaking (1.1.2.3)
  - Earth's history (1.1.2.4)
  - Earth in the solar system (1.1.3.1)
  - Planets in the solar system (1.1.3.2)
  - Evolution of the universe (1.1.3.4)
  - Types of forces (gravitational force) (1.3.6.1)
  - Pollution (1.6.1)
  - the following TIMSS performance expectations/science processes are most emphasised:
  - Understanding simple information (2.1.1) (14 activities)
  - Accessing and processing information (2.5.1) (11 activities)
  - Sharing information (2.5.2) (11 activities)
  - Interpreting data (2.3.5) (10 activities)
  - Understanding complex information (2.1.2) (10 activities)
  - Constructing, interpreting and applying models (2.2.4) (9 activities)
  - Making decisions (2.2.5) (9 activities)
    (The specific expectations *'making decisions'* and *'constructing, interpreting and applying models'* falls under the more general category - *'theorizing, analyzing, and solving problems*')
  - Organising and representing data (2.3.4) (8 activities)
- the following TIMSS performance expectations/science processes are included but less emphasised:
  - Gathering data (2.3.3) (4 activities)
  - Identifying questions to investigate (2.4.1) (2 activities)
  - Applying scientific principles to develop explanations (2.2.3) (2 activities)
  - Designing investigations (developing hypotheses) (2.4.2) (1 activity) (*'Designing investigations'* falls under the more general category *`investigation the natural world'* (conducting investigations) from the TIMSS Science framework.)

4.3 Resume

The study of the intended curriculum revealed that:

- all eleven teachers held a common intended curriculum. They all intended following the PSP Learning Programme;

- the Learning Programme that the eleven teachers intended following in their Grade 7 Natural Sciences programmes in the second term was guided by activity-based classroom methods advocated by the broad principles of OBE; and

- all the teachers intended using the same curriculum material (PSP activities) for their Grade 7 teaching of the Natural Sciences in the second term.

The analysis of the intended curriculum revealed that:

- although Curriculum 2005 can be used as a tool for analysing and identifying the outcomes/processes to be applied in the teaching of PSP's Grade 7 Natural Sciences Learning Programme and activities,

  a) the outcomes/processes are general;

  b) the curriculum content performance expectations, and values aspects are embedded in the outcomes (rather than made explicit) and therefore, peripheral to the processes/outcomes;

- because the TIMSS Curriculum Framework for Science provides lists of specific content topics/subtopics, lists of performance expectations (the kinds of tasks learners *`are expected to be able to perform for specific contents'*, in other words, *'performable tasks rather than cognitive processes )*[14]*,* and lists of perspectives, the Framework makes it possible to analyse and classify the content, performance expectations and perspectives/values aspects *(`more generic, less culture bound task demands')* of the PSP Learning Programme/curriculum material into discrete categories and subcategories, each with its own identity.

14 'Specific cognitive or thought processes might lie behind the performance of these tasks. However, characteristic thought processes are more closely tied to the culture in which education occurs. Specific tasks in school science and mathematics are more likely to be widely common among countries and less tied to specific cultures. Thus they are more appropriate for cross-national comparisons (which are also necessarily multicultural)'. (Schmidt et al, 1997b:39).

5. STUDYING THE SOCIAL AND EDUCATIONAL CONTEXTS OF LEARNING

In Section 4 of this report, we provided a description of the Natural Sciences concepts and processes that learners were expected to gain through the intended curriculum (the PSP's Learning Programme). Section 4 also provided information on the activities that teachers intended using in their Natural Sciences lessons.

However, the conceptual framework of learners' `opportunity to learn' in TIMSS included a number of integrated (educational and social) contextual variables or factors that could contribute to similarities or differences in teacher effectiveness and learner achievement. Thus Section 5 of this report provides information on:

- aspects of the social and educational contexts for learning and teaching (contexts within which the sample of Grade 7 learners learn Natural Sciences) that could have contributed to similarities in teacher effectiveness and learner achievement; as well as
- variables in the social and educational contexts of learning and teaching that could have contributed to differences in teacher effectiveness and learner achievement.

5.1 Social context

The social context in which the sample of schools operated is described in terms of local community characteristics (see 5.1.1) and learners' backgrounds and home environments (see 5.1.2).

5.1.1 Local community characteristics Principals at all ten schools reported that: • most or all of their learners came from poverty-stricken backgrounds;

- some, most or all of their learners came from homes where their parents/main caregivers did not receive more than primary schooling;
- some or most of their learners came from homes that do not have electricity; and
- some or most of their learners have health or nutrition problems. School location

The ten schools used in the study are situated in the following townships or settlements near Cape Town:

- Guguletu (2 schools)
- Nyanga East (1 school)
- Philippi (1 school)
- Khayalitsha (5 schools)
- Langa (1 school)

Primary language(s) of learners at home

Principals at all ten schools reported that the primary language of the majority of learners at home was Xhosa.

Principals reports on the primary languages of minority groups of learners indicated that there were minority groups of learners who spoke languages other than Xhosa at home at 5 of the ten schools (Schools 1,6,7,8,9).

5.1.2 Learners' backgrounds and home environments

60% of the learners reported that between 4-7 people lived in their homes. 23% of the learners reported that more than 7 people lived in their homes. 33% reported that they had their own bedroom at home.

79% of learners reported that they had electricity at home. 44% reported that they had running water in their houses. 18% reported that they had warm water in their houses.

86% reported that they had a radio in their houses. 83% reported that they had a television in their houses. 74% reported that they had a tape recorder in their houses. 32% reported that they a CD player in their houses. 30% reported that they did not have a video machine in their houses.

74% of the learners reported that they had fewer than 26 books in their homes. 48% of learners reported that they had a study desk/table at home. 81 % of learners reported that they had a calculator at home. 70% reported that they had a dictionary at home. 6% of learners reported that they had a computer at home. 37% reported that there was a motor car available at their homes. 21 % reported that they owned a bicycle.

Data from learners' reports on how far their fathers studied in/after school +indicated that:

- 45% of the learners did not know;
- 6% of learners reported that their fathers had completed vocational or technical education after secondary school;
- 9% of learners reported that their fathers had completed university study;
- 15% of learners reported that their fathers had completed secondary school; and
- 18% of learners reported that their father had completed primary school. (7% of learners' responses were missing).

Data from learners' reports on how far their mothers studied in/after school indicated that:

- 26% of the learners did not know;
- 5% of learners reported that their mothers had completed vocational/technical education after secondary school;
- 11 % of learners reported that their mothers had completed university study;
- 30% of learners reported that their mothers had completed secondary school;
- 21 % of learners reported that their mothers had completed primary school. (7% of learners' responses were missing).

Data from learner's reports indicated that 86% of learners in all the classes never, or rarely spoke English at home.

81 % of learners reported that their parents or caregivers think it is important for them to do well in Natural Sciences at school. 90% reported that their parents or caregivers think it is important for them to do well in English at school. 77% of learners reported that their parents or caregivers thought it important for them to be good at sports. 65% reported that their parents or caregivers thought it important for them to have time to have fun.

Peer influence

92% of learners reported that their friends think it is important to do well in Natural Sciences at school. 94% reported that their friends think it is important to do well in English at school. 81 % of learners reported that their friends think it is important to be good at sports. 69% reported that their friends think it is important to have time to have fun.

5.2 Educational contexts

The educational context is described in terms of school (see 5.2.1), teacher (see 5.2.2) and classroom characteristics (see 5.2.3), and learners' experience of the educational context (see 5.2.4).

5.2.1 School characteristics

All ten schools are former DET schools. None of the schools have platoon/ double shift systems. School 5 is a community school that is only partially funded by the education department.

According to principals' reports on the total enrolment at each school, four of the schools had an enrolment of more than one thousand learners. School 10 had the largest enrolment of the ten schools (1739). School 8 had the smallest enrolment of the ten schools (670). The average enrolment at the schools was 1043.

Principals' reports on the number of full-time staff at the schools and learner enrolment indicated that the teacher: learner ratio at the schools ranged from 33:1 at school 2 to 53:1 at school 10. The data indicated that five of the schools had ratios of between 30-39:1. Four of the schools had ratios of between 40-45:1.

Eight of the school principals reported that they had been principal at their schools for 5 or more years. One principal reported that he/she had been principal for 3-4 years. One principal reported that he/she had been principal at the school for 1-2 years.

Principals at four of the schools reported that there were no factors that influenced or determined learner admission to their schools. Principals at two schools said that preference was given to learners whose primary language was the same as the majority of learners at the school. Four of the ten principals reported that the factor that most influenced or determined learner admission to their schools was the date of learners' application.

The factor most frequently cited by school principals as most affecting their schools' capacity to provide instruction in the Natural Sciences was a shortage of library materials relevant to the Natural Sciences. Other factors most commonly cited by principals as affecting schools' capacity a lot or to some extent were a shortage of computers for Natural Science instruction; inadequate facilities for duplicating worksheets; and a shortage of audio-visual resources for Natural Sciences instruction.

A shortage of electricity was the factor least cited by all principals as affecting their schools' capacities to provide science instruction. Inadequate instructional space; a shortage of instructional material; shortages of school buildings; inadequate budgets for supplies; inadequate heating/cooling and lighting systems; and shortages of chairs, desks and tables were cited as affecting the i schools' capacity to a lesser extent.

According to the principals' reports, the total number of Grade 7 learners at the schools ranged from 147 at School 6 to 68 at School 1. The average number of Grade 7 learners at the schools was 112. The number of Grade 7 learners repeating the year varied from 0-6. The average number of Grade 7 learners repeating at the schools was 3. According to principals' reports, the size of Grade 7 classes ranged from 31-73.

Principals at the ten schools reported that all learners in Grade 7 follow the same curriculum in the Natural Sciences. Principals at all the schools said that the Primary Science Programme's Learning Programme had a lot of influence in determining the Natural Sciences curriculum taught at their schools. Natural Sciences teachers as a group, textbooks, and teachers collectively for the whole school had some influence in determining the curriculum at most of the schools. According to the principals' reports the school governing body, principal, and National Department of Education had no or little influence over the curriculum at most of the schools, whilst individual Grade 7 teachers and the Provincial Education Department had little or some influence.

Six of the principals reported that there were no computers available at their schools. The four principals who reported that their schools had computers reported that they were used by office staff for record keeping. Only one school reported having a computer available for general use by learners.

Principals' reports on the behaviour of Grade 7 learners indicated that learners arrived late at school on a daily basis at all ten schools. The second most common problem cited was that of learner absenteeism. Six of the ten school principals reported that this occurred on a daily basis, whilst four of the school principals indicated that absenteeism rarely occurred. The third most common problem cited was that of learners skipping class. Three school principals indicated that this occurred daily, two schools reported that this occurred weekly, and four schools indicated that this occurred rarely.

The fourth, fifth and sixth most frequent problems at the schools were learner intimidation or verbal abuse of other learners; learners creating classroom disturbances; and learners making physical threats or causing injuries to other learners.

Problems least cited *(monthly, rarely* or *never)* at the schools were intimidation or verbal abuse of staff by learners; vandalism by learners; and physical threats or injuries to staff by learners.

Institutional arrangements at the schools

Principals' reports on the number of instructional hours at the schools revealed that the number of hours ranged from 22 to 28 hours per week (excluding breaks, assemblies, extra-mural activities etc.). According to principals' reports the number of hours teaching time that they anticipated would be lost in the second term ranged from none (at two schools); two hours at two schools; two and a half hours at one school; four hours at two schools; four and a half hours at one school; six and half at one school; and eight hours at one school.

Principals' reports on the number of minutes in a typical instructional period indicated that nine of the ten schools had 30 minute periods. School 6 had 45 minute periods.

Principals' reports on who had primary responsibility for school activities indicated that teachers had primary responsibility at:
- all the schools for deciding what textbooks to use;
- nine of the schools for establishing homework policies;
- eight of the schools for placing learners in classes;
- seven of the schools for establishing assessment and learner grading policies;
- six of the schools for determining subject content; and
- six of the schools for communicating with learners' families.

The reports indicated that principals had primary responsibility at:
- all the schools for assigning teachers to classes;
- five of the schools for establishing community relations.

Governing bodies at three of the ten schools had primary responsibility for
- establishing community relations; and
- establishing disciplinary policies.

According to principal's reports Grade 7 learners at all the schools wrote internal examinations. Seven principals reported that Grade 7 teachers collectively were responsible for setting the Grade 7 Natural Sciences examination. Three principals reported that individual Grade 7 teachers were responsible for setting the examination.

Principals at all ten schools reported that Grade 7 Natural Sciences teachers met regularly to discuss teaching goals and that more experienced teachers at their schools supported and mentored junior or less experienced teachers. Principals at eight of the schools reported that their schools had an official policy related to promoting co-operation and collaboration among teachers. Principals at Schools 6 and 9 reported that their schools did not have official policies.

Principals at five of the schools reported that there were three Grade 7 classes. Principals at five of the schools reported that there were two Grade 7 classes.

5.2.2 Teacher characteristics

All eleven teachers reported that Xhosa was their primary language. Six of the teachers were female, and five were male.

Seven of the teachers reported that they were between 30-39 years of age. Two teachers reported that they were between 40-49 years of age. One teacher reported that she/he was between 25-29 years of age. One teacher reported that she/he was between 50-59 years of age.

Five teachers reported that the highest formal level of education they had completed was Matric plus three years of teacher training. Four teachers reported having completed Matric plus four or five years of teacher training. Two teachers reported that they had completed Bachelor degrees plus teacher training. Thus, none of the teachers was classified as under-qualified in terms of the COTEP document.

Six of the eleven teachers reported that their last formal academic/teaching qualification was achieved in the last six years. Two teachers reported that the year that their last formal qualification was achieved was 1984 (fourteen years ago). One teacher reported that his/her last qualification was achieved in 1986; one teacher reported that her/his last qualification was achieved in 1989; and one teacher reported that he/she achieved his/her last academic/formal qualification in 1991.

Teachers 3 and 8 reported having 22 and 23 years teaching experience respectively. Teachers 2 and 10 reported having 11 and 13 years experience respectively. The remaining seven teachers all had less than ten years teaching experience. Only one of these teachers (Teacher 9) reported having less than five years experience.

Only two teachers, Teachers 9 and 11, reported that they were not Natural Sciences specialists. Teacher 9 said she had not taken Science for Matric and had not studied it at college. Teacher 11 reported that he had not majored in Science on related subjects at college.

Of the nine teachers who said they were subject specialists:

- Teacher 1 reported that that he had taken Science for Matric and had studied Biology for 3 years at teacher training college;
- Teacher 2 reported that she had taken Science for Matric and had majored in Science at teacher training college;
- Teacher 3 said that he had majored in Geography at college;
- Teacher 4 said she had taken Science for matric and had studied Science at college for three years;

- Teacher 5 reported that she had not taken Science for Metric but had majored in Science at teacher training college;
- Teacher 6 reported that he had taken Science for Metric and had studied Science at teacher training college;
- Teacher 7 said she had studies Science for Matric and had majored in Science at college;
- Teacher 8 said she had taken Biology for Matric and had studied Science up to std 8;
- Teacher 10 reported that he had taken Science for Matric and had majored in Science at college.

None of the eleven teachers reported that they had taught Natural Sciences to Grades lower than Grade 5 (std 3) in the past 5 years. Teacher 10 was the only teacher who reported that he/she had taught Natural Sciences to a Grade higher than Grade 7 (Grade 8) in the past 5 years

According to PSP records five of the teachers had attended two of the four PSP workshops on the Learning Programme held prior to the post-tests. Five of the teachers had attended three of the PSP workshops; and one teacher had attended all four of the PSP workshops. All four workshops dealt with the implementation of the Learning Programme.

Teachers' reports on time spent on school activities outside the formal school day indicated that teachers spent the most time preparing/marking learner tests/ exams, reading/marking other learner work, or planning lessons by themselves (3-4 hours on each per week). Teachers reported that they spent the least time giving extra lessons, on union/teacher organisation activities, and meeting with parents/care-givers (on average less than 1 hour on each per week). Teachers' reports indicated that on average they spent 1-2 hours per week on professional development activities, administrative tasks, and keeping learner records up to date.

Two teachers reported that they never met with other Grade 7 Natural Science teachers at their schools. One of these teachers said this was because she was the only Grade 7 Natural Science teacher. Three teachers reported that they met with other teachers in their subject area once a month to discuss and plan their Grade 7 Natural Science curriculum and teaching approaches. Three teachers reported that they met once a week. One teacher reported that they met once or twice a year. One teacher said that they met once every second month. One teacher reported that they met 2/3 times per week, and one teacher reported that teachers met almost every day.

Seven teachers reported that they felt well-prepared and confident about teaching the Learning Programme. Three teachers said they felt somewhat prepared and confident about teach the Learning Programme.

Three of the eleven teachers reported that teaching was their first choice of career, and eight teachers reported that it was not their first choice. Four teachers reported that they would change to another career if they had the opportunity. All eleven teachers said they believed that society and their learners appreciated their work.

Five teachers reported that they had more than 200 books in their homes. Two teachers reported having 101-200 books at home. Three teachers reported that they had 26-100 books in their homes. One teacher reported having 11-25 books in his/her home.

5.2.3 Classroom characteristics

Teachers' reports revealed that the size of the smallest Grade 7 Natural Science class tested for the study was 31. The size of the largest class was 72. Overall four classes had between 30-39 learners; four classes had between 40-49 learners; two classes had between 65-69 learners; and one class had over 70 learners. The average class size was 47.

Data provided by the teachers on the year of birth of the sample of learners showed that the average age of learners in the eleven classes according to learners' year of birth was 14,15 years. Learners who start school at the age of seven and progress uninterruptedly through school should turn 13 in Grade 7. Table 11 provides data on the average age of learners-for-each class.

TABLE 11: AVERAGE AGE OF LEARNERS IN EACH CLASS

TEACHER	AVERAGE AGE
1	14.33
2	14.72
3	13.16
4	15.21
5	14.02
6	13.98
7	13.97
8	13.5
9	14.20
10	14.43
11	14.19

Five teachers reported that the majority of learners in their classes had middle achievement levels in Natural Sciences; three teachers reported that the majority of learners had middle to low achievement levels; and three teachers reported that the majority of learners had low achievement levels. None of the teachers reported that the majority of learners in their classes had high achievement levels.

Teachers' reports on the average number of minutes per week available for teaching Natural Science teaching to their Grade 7 classes indicated that time ranged from 90 minutes (Teachers 7 and 8) to 240 minutes (Teacher 5). One teacher reported that 105 minutes were available for Natural Sciences lessons. One teacher reported 135 minutes. Two teachers reported that 150 minutes were available per week. Four teachers reported 180 minutes. On average 152 minutes were available for teaching Natural Sciences.[15]

All eleven teachers reported that they gave their Grade 7 classes Natural Sciences homework. One teacher reported that he/she gave learners homework in the Natural Sciences less than once a week. Seven of the eleven teachers reported that they gave learners homework once or twice a week. Four teachers reported that they gave learners homework 3/4 times per week.

Teachers' reports on their use of learners' written Natural Sciences homework indicated that teachers most usually:

- used homework to give feedback to the whole class;
- collected, corrected homework and returned it to the learners; or used homework to contribute towards learners' marks.

According to teachers' reports teachers never or rarely:

- had learners exchange homework and correct them in class; or had learners correct their own homework in class.
- Ten of the eleven teachers reported that they tested their Grade 7 Natural Sciences classes. Six teachers reported that they tested their learners at least once a week. Four teachers reported that they tested their learners at least once a month.

Six teachers reported that they team teach their Grade 7 Natural Sciences classes. Two teachers (both at the same school) said that team teaching took place daily. One teacher said that this happened 2-3 times per week. Three teachers said they team teach their classes at least once a month. Five teachers said that they never team teach their classes.

According to teachers' reports on what factors limited how they taught their Grade 7 classes Natural Sciences, the five factors that most limited their teaching were:

- learners with different academic abilities;
- parents who were uninterested in their children's progress;
- a shortage of equipment for use in demonstrations and other exercises;
- insufficient instructional space; and
- high teacher/learner ratios.

The six factors that least limited how they taught their classes were:

- threats to their personal safety or the safety of the learners;
- low morale among teachers/school administrators;
- learners with special needs;

[15] A number of teachers reported that, as they were one of two teachers teaching 'General Science' (Biology and Physical Science) to their Grade 7 classes, they had to 'share' the teaching and learning time allocated. As a result, the time available for teaching 'Natural Sciences' amounted to half the time that had been reported available by principals in the initial survey questionnaire and the school questionnaire.

- learners who come from a wide range of backgrounds;
- disruptive learners; and
- uninterested learners.

Data from teachers' reports on the number of Natural Sciences lessons `missed' in the second term provided an indications of factors that tend to limit or interrupt the 'flow' of Natural Sciences classes. According to teachers' reports, the number of Natural Sciences lessons learners missed in the second term ranged from 0 to 27 lessons. On average teachers reported that learners missed 10 Natural Sciences lessons in the second term.

Table 12 provides the total number of Natural Sciences lessons teachers reported their Grade 7 learners had missed in the second term. The Table also summarises the reasons for the lessons missed, and provides an indication of the number of lessons missed for each reason.

TABLE 12: TOTAL NUMBER OF NATURAL SCIENCES LESSONS MISSED IN THE SECOND TERM

TEACHER	TOTAL NO OF LESSONS MISSED	NO OF LESSONS MISSED FOR REASON	REASON
1	4	4	Teacher mass action
2	10	1 2 3 2 2	Teacher mass action Urgent staff meetings Teacher counseling parent/s Class excursions Sporting activities
3	0	0	
4	16	2 2 2 6 4	Teacher mass action Urgent staff meetings Class excursions Personal bereavement No reason provided
5	7	5 2	Urgent staff meetings Low learner attendance after exams
6	27		Combination of factors (e.g. early closing on Fridays, General Science periods had to be shared with the Biology teacher so learners had 3/2 instead of 5 lessons per cycle)
7	9	3 19	Teacher personal bereavement Combination of factors (in particular, the fact that the teacher had to share General Science lessons with the Biology teacher. Other factors included re-organisation of the timetable because teachers had taken retrenchment 'packages').
8	3	1 2	Teacher ill-health Teacher writing exams

TABLE 12: (contd)

TEACHER	TOTAL NO. OF LESSONS MISSED	NO. OF LESSONS MISSED FOR REASON	REASON
9	15	10	Teacher mass action
		1	Urgent staff meetings
		1	Class excursions
		2	Teacher ill-health
		1	*Combination of factors*
10	7	6	Teacher mass action
		1	Urgent staff meetings
11	7	6	Teacher mass action
		1	Urgent staff meetings

The factor most cited by teachers as the reason for learners missing Natural Science lessons in *the* second term was teacher mass action. This was the reason that six teachers gave for learners in their classes missing a combined total of 23 lessons across the six classes. The second most common reason given by teachers for learners missing lessons was that of ad hoc staff meetings called during teaching time (according to six teachers learners in their classes missed a combined total of 8 lessons for this reason). These meetings may, however, have been related to the proposed stay away.

Class excursions were cited by three teachers as the reason for their learners missing three Grade 7 Natural Sciences lessons overall. Two teachers cited teacher ill-health as the reason for their classes missing three lessons overall. One teacher said his/her class had missed three lessons because he/she had had to counsel parents during teaching time. One teacher said her/his class had missed two lessons because of sporting activities. Two classes missed a total of nine lessons because their teachers had suffered bereavements. One teacher reported that her/his class had missed two lessons because of low learner attendance after the examinations had finished.

Some teachers reported that their classes missed approximately half the allocated Grade 7 Natural Science lessons because their classes had to `share' their `Science' lessons with the Biology teacher. In other words, teachers reported that their schools are offering separate courses in the two different sciences at the Grade 7 level.

5.3 Learner characteristics

Of the sample of learners, 54% were girls, and 46% were boys.

Data provided by teachers on the year of birth of the sample of learners indicated that 37% of learners were 13 years and younger; 63% were 14 years and older. Learners who start school at the age of seven and progress uninterruptedly through school should turn thirteen in Grade 7. Thus data indicated that 63% of the sample of learners were above the norm of thirteen years of age at the time of testing.

5.3.1 The learners' experience in the educational context

The majority of learners reported that they believed that "hard work studying at home" (87%) and "memorising textbooks/notes" (77%) was required to achieve in Natural Sciences.

7% of learners reported skipping a class in the last month of school. 68% of learners reported that in the last month of school something of theirs had been stolen. 23% of learners reported that in the last month of school they had thought that another learner might hurt them. 27% of learners reported that some of their friends had skipped classes in the last month at school. 41 % reported that some of their friends had had things stolen in the last month. 38% of learners reported that some of their friends had been hurt by other learners in the last month.

5.4 Resume

Data on the social and educational contexts for learning indicated that the sample of schools, teachers and learners form relatively homogenous groups.

However, data also revealed key school and classroom variables and/or variables in teacher backgrounds that could contribute to differences in learner achievement, and that might be related to teacher effectiveness. Tables 13-15 that follow summarise key school (Table 13), teacher (Table 14), and classroom variables (Table 15). The tables reveal variables in school characteristics such as school enrolment; teacher characteristics such as teachers' experience, qualifications and attendance at PSP workshops; and classroom characteristics such as class size; average age; class size; the number of Natural Sciences lessons missed, etc. The study also reveals key variables in learner characteristics such as gender, age, number of books at home, parents' educational levels, etc.

TABLE 13: KEY SCHOOL VARIABLES

SCHOOL	LOCATION	MINORITY GROUPS OF LEARNERS WHOSE PRIMARY LANGUAGE IS NOT XHOSA	HOW LONG PRINCIPAL HAS BEEN PRINCIPAL AT THE SCHOOL	SCHOOL ENROLMENT	TEACHER: LEARNER RATIO	LENGTH OF TYPICAL LESSON	NO OF PERIODS IN A DAY	NUMBER OF INSTRUCTIONAL HOURS IN THE SCHOOL WEEK
1	Guguletu	Yes	5 or more years	910	38	30	11	28
2	Khayelitsha	No	5 or more years	820	33	30	9	26
3	Khayelitsha	No	5 or more years	912	36	30	10	26
4	Langa	No	5 or more years	914	40	30	11	25,5
5	Nyanga East	No	5 or more years	1095	44	30	10	25
6	Khayelitsha	Yes	5 or more years	1495	40	45	7	25
7	Khayelitsha	Yes	1-2 years	683	40	30	10	25
8	Guguletu	Yes	5 or more years	670	35	30	11	22
9	Philippi	Yes	5 or more years	1193	37	30	11	27
10	Khayelitsha	No	3-4 years	1739	53	30	10	25

TABLE 14: KEY VARIABLES IN TEACHER CHARACTERISTICS

TEACHER	AGE	GENDER	HIGHEST LEVEL OF EDUCATION	YEAR IN WHICH LAST ACADEMIC QUALIFICATION ACHIEVED	NUMBER OF YEARS TEACHING EXPERIENCE	HOW WELL-PREPARED TEACHER FEELS TO TEACH PSP LEARNING PROGRAMME	TEACHING FIRST CHOICE OF CAREER?	TEACHER WOULD CHANGE TO ANOTHER CAREER IF HE/SHE HAD THE OPPORTUNITY	NUMBER OF BOOKS IN TEACHER'S HOME	NUMBER OF PSP WORK-SHOPS ATTENDED
1	25-29	M	M+3 tt	1993	5	Well prepared	Yes	No	26-100	2
2	30-39	F	M+4/5 ttt	1986	11	Somewhat prepared	No	Yes	More than 200	2
3	40-49	M	M+4/5 tt	1998	22	Somewhat prepared	No	No	More than 200	3
4	50-59	F	M+4/5 tt	1995	8	Well prepared	No	No	11-25	2
5	30-39	F	M+3 tt	1989	8	Somewhat prepared	No	No	26-100	2
6	30-39	M	M+3 tt	1991	7	Well prepared	Yes	Yes	101-200	4
7	30-39	F	B.Degree + tt	1996	9	Somewhat prepared	No	Yes	101-200	3
8	40-49	F	B.Degree + tt	1997	24	Well prepared	Yes	No	26-100	3
9	30-39	F	M+3 tt	1993	3	Well prepared	No	Yes	More than 200	2
10	30-39	M	M+4/5 tt	1984	13	Well prepared	No	No	More than 200	3
11	30-39	M	M+3 tt	1984	8	Well prepared	No	No	More than 200	3

TABLE 15: KEY CLASSROOM VARIABLES

TEACHER	CLASS SIZE	AVERAGE AGE	MINUTES AVAILABLE FOR TEACHING NATURAL SCIENCE PER WEEK*	NUMBER OF NATURAL SCIENCES LESSONS MISSED IN THE SECOND TERM
1	32	14.33	180	4
2	48	14.72	150	10
3	40	13.16	150	0
4	32	15.21	180	16
5	37	14.02	240	7
6	67	13.98	135	27*
7	31	13.97	90	22*
8	37	13.50	90	3
9	49	14.20	105	15
10	72	14.43	180	7
11	68	14.19	180	7

* Teachers reported that they had to 'share' the time allocated to 'General Science' with the Biology teachers. This meant that approximately half of the allocated time was available for teaching Natural Sciences (see Table 2 on page 15).

6. STUDYING THE IMPLEMENTED CURRICULUM

Section 5 of this report provided background information on:

- the characteristics of the teachers who were teaching the Learning Programme;
- the ways that Natural Sciences teaching and learning at the schools was organised (for example, the time allocated for Natural Sciences lessons);
- key characteristics of the eleven Grade 7 Natural Sciences classes; and
- learner characteristics such as their age, gender, and the socio-economic status of their families.

This section of the report examines the ways in which learners' learning experiences and opportunities to learn were similar or differed across the twelve classrooms. In particular, Section 6 provides information on the implemented curriculum in terms of the following:

- the extent of coverage of the PSP's Learning Programme (see 6.1)
- the researchers' reports on teachers' classroom practices in Grade 7 Natural Sciences classes (see 6.2)

6.1 Extent of coverage of the Learning Programme

There were 48 teaching days in the second term of 1998. Under ideal conditions the sample of learners should have received at least 8 weeks of schooling (given that approximately 2 weeks of the 10 week term were taken up with end of term examinations at the schools).

Tables 16-18 provide information on teachers' coverage of the Learning Programme.

Table 16 provides the number of Natural Science lessons and amount of teaching/learning time in minutes that teachers' reported their Grade 7 classes actually received between the pre- and post-tests (as opposed to the number of minutes available for teaching Natural Sciences). The Table also provides information on the PSP activities that teachers said they had managed to cover in the second term.

TABLE 16: NUMBER OF LESSONS, MINUTES OF NATURAL SCIENCES TEACHING, AND ACTIVITIES COVERED

TEACHER	NO. OF NATURAL SCIENCE LESSONS	DURATION OF AVERAGE LESSON	TEACHING/ LEARNING TIME IN MINUTES	PSP ACTIVITIES COVERED
1	22	30	660	1-9 & 11
2	17	30	510	1-7
3	27	30	810	1- 11
4	14	30	420	1-5 & 11
5	20	30	600	1-7 & 9 & 11
6	13	45	585	1-7
7	15	30	450	1-6 & 11
8	14	30	420	1-6
9	16	30	480	1-9 & 11
10	23	30	690	1-8 & 11
11	23	30	690	1-8 & 11

Table 17 provides details about the number of teachers who reported that they had covered individual activities.

TABLE 17: NUMBER OF TEACHERS WHO COVERED ACTIVITIES

ACTIVITY NUMBER	NUMBER OF TEACHERS WHO COVERED THE ACTIVITY
1: Earth is round	11
2: Inside Earth	11
3: Big Bang	11
4: Sun and its family	11
5: Where is land, water, air	11
6: My little piece of Earth	10
7: Layers of the atmosphere	8
8: Travel to outer space	5
9: Earth's photograph	4
10: *Continental drift*	1
11: Water cycle	8

Table 18 provides an indication of the extent of teachers' coverage of the content (topics/subtopics) covered in the TIMSS item tests `matched' to the PSP activities.

TABLE 18: TEACHERS' COVERAGE OF THE CONTENT

TIMSS ITEM TEST MATCHED TO ACTIVITY	ACTIVITY AND NUMBER OF TEACHERS WHO COVERED ACTIVITY	AVERAGE NUMBER OF LESSONS IN WHICH ACTIVITY/ CONTENT WAS COVERED	ESTIMATED NUMBER OF MINUTES IN WHICH TEST ITEM CONTENT WAS COVERED ON AVERAGE*
B1	2 Inside Earth (all teachers)	3 lessons	90 minutes
F4	12 Rocks (not covered by any of the teachers)	-	-
F5	5 Land, water, air (all teachers) 6 Piece of Earth (10 teachers) 7 Layers of the atmosphere (8 teachers) 8 Outer space (5 teachers)	1,5 lessons 2 lessons 2 lessons	165 minutes
H3	4 Solar system (all teachers) 9 Earth's photo (4 teachers)	3 lesson 0,5 lesson	105 minutes
H4	13 Soil (not covered by any of the teachers)	-	-
I17Energy for Earth's water cycle	11 Water cycle (eight teachers)	2 lessons	60 minutes
J1 Which describe Earth's surface?	10 Continental drift (only one teacher covered this activity)	-	-
K17 Which position gravity act?	3 Big Bang (all teachers) 4 Solar system (all teachers) 6 Piece of Earth (10 teachers) 8 Outer space (5 teachers)	3 lessons 3 lessons 2 lessons 1 lesson	270 minutes
N5 Principal cause of acid rain	14 Precious Earth (not covered by any of the teachers)	-	-
012 Which gas greatest amount	5 Land, water, air (all teachers) 4 Solar system (all teachers) 7 Layers of the atmosphere (8 teachers)	1,5 lessons 3 lessons 2 lessons	195 minutes
014 Sun and Moon	4 Solar system (all teachers)	3 lessons	90 minutes
P3 Life on another planet	4 Solar system (all teachers) 7 Layers of the atmosphere (8teachers) 8 Outer space (5 teachers)	3 lessons 2 lessons 1 lesson	180 minutes
Q11 Why daylight and darkness occur?	1 Earth is round (all teachers) 4 Solar system ((all teachers)	1 lesson 3 lessons	120 minutes
R4 Ozone layer	7 Layers of the atmosphere (8 teachers)	2 lessons	60 minutes
W1A & B River on the plain/good place	13 Soil (not covered by any of the teachers)	-	-
W2 Rain from another place	11 Water cycle (8 teachers)	2 lessons	60 minutes
W5 (Pop1 item) Reducing air pollution	7 Layers of the atmosphere (8 teachers) 14 Precious Earth (not covered by any teachers)	2 lessons	60 minutes
Z2 Not enough water	5 Land, water, air (all teachers) 11 Water cycle (eight teachers)	1,5 lessons 2 lesson	105 minutes

* The average number of minutes was calculated in terms of 30 minute periods for those teachers who said they had covered the activity. However, not all teachers covered all the activities

Data from the three tables above reveals that, according to teachers' reports:

- none of the teachers completed the intended fourteen activities. Only one of the teachers managed to cover eleven of the activities. One teacher only managed to cover six of the activities. On average teachers covered eight of the fourteen PSP activities in the second term;
- the number of minutes of Natural Science teaching and learning in the eleven classes varied from a minimum of 420 minutes to a maximum of 810 minutes. On average learners received 574 minutes of Natural Science teaching and learning in the second term. By implication, during the eight weeks available for teaching in the second term learners across the eleven classes had an average of just over 70 minutes of Natural Sciences lessons per week;
- the number of Natural Science lessons in the second term ranged from a minimum of 13 lessons to a maximum of 27 lessons. On average learners received 18.5 Natural Science lessons in the second term. By implication, on average learners across the eleven classes had 2.3 Natural Sciences lessons per week in the second term;
- teachers did not always follow the original sequence of the activities in the Learning Programme.

The analysis of teachers' coverage of the Learning Programme through the use of the activities:

- revealed discrepancies between the intended curriculum goals as expressed in the Learning Programme, and the curriculum that the teachers managed to implement during the second term of 1998.
- provides evidence that disruptions in schools and teaching, and,. consequently, the 'flow' of Natural Sciences lessons, may have been major obstacles to the thorough development of the intended. concepts, processes and language.

6.2 Reports on teachers' instructional practices in Grade 7 Natural Sciences classes

The following section provides information on the implemented curriculum in terms of how teachers used the PSP activities. Reports on teachers' instructional practices are based on:

- aspects of teachers' lessons that were observable; and
- information obtained through direct interviews with teachers after they had finished teaching the lessons.

6.2.1 Lesson context and teachers' teaching strategies

Section 6.2.1 provides information on:

- the lesson context such as the length of the lesson observed, the number of learners present in the classes, the activity (topic(s)) covered in the observed lesson, the classroom conditions, the lesson venue/location etc (6.2.1.1); and
- the `outward forms' of teachers' teaching strategies such as the types of classroom organisation used by the teacher in the lessons observed; the way in which the teacher structured the lessons; the teachers' organisation and use of support material; the teachers' organisation of the tasks/activities; the language(s) of learning and teaching; and the extent and type of learner participation and involvement in the lessons (6.2.1.2).

6.2.1.1 The lesson context

Length of lessons observed

According to the researchers' reports, the length of the lessons observed varied from 30-90 minutes. Nine of the lessons were observed for 30 minutes. Nine of the lessons were observed for 60 minutes. Three lessons were observed for 45 minutes. One lesson was observed for 90 minutes. Teachers at some schools appeared to have made special arrangements for the length of their Natural Sciences lessons to be extended when they were observed as they felt that additional time was required for them to organise the activities effectively.

Number of learners absent/present in the classes

Table 19 provides data on the number of learners present and the number of learners who were absent for the lessons observed.

TABLE 19: NUMBER OF LEARNERS PRESENT/ABSENT

TEACHER	LESSON 1		LESSON 2	
	No. present	No. absent	No. present	No. absent
1	32	2	34	0
2	45	3	48	0
3	35	5	35	5
4	30	2	28	4
5	32	3	31	4
6	55	12	54	13
7	30	1	27	4
8	27	10	31	6
9	46	3	46	3
10	66	6	64	8
11	53	15	65	3
Ave		62÷11 = 5,6		50÷11 = 4,5

The highest percentage of learners absent from the lessons observed was 24% (Teacher 6's class).

Lesson venue/location

The researchers reported that twenty-one of the twenty-two lessons observed took place entirely inside classrooms. In one lesson, the teacher (Teacher 3) took the class outside to do the `dance *of* the solar system' (see Activity 4). Classroom conditions

During lesson observations the researchers noted that:

- all the classrooms had usable chalkboards, sufficient seating for learners, and adequate lighting and ventilation;
- the temperature in ten of the classrooms was comfortable. One classroom was `too warm',
- there was noise or outside distraction in two of the eleven classrooms;
- eight of the classrooms had tables for the teacher and sufficient space for learners. Three teachers had taken their tables out of the rooms because there was insufficient space to accommodate all the learners and the teachers' table; and
- only six of the eleven classrooms had cupboards or storage space.

Activities covered

Researchers reports on the activities covered in the observed lessons showed that:

- Activities 6 (My little piece of Earth) and 11 (Water cycle) were the activities used the most in the observed lessons (at least six lessons each);
- Activity 3 (Big Bang) was used in four lessons;
- Activity 4 (the Solar System) was used in three lessons;
- Activity 8 (Travelling to outer space) was used in two lessons;
- Activity 7 (Layers of the atmosphere) was used in one lesson. Type of lesson

The majority (approximately 70%) *of* the lessons observed were introductory lessons (i.e. teachers were introducing the activity/lesson topic). The balance of the lessons observed (approximately 30%) were either a continuation of previous lessons or the end of a number of lessons.

Teachers' main source when deciding what to teach
All the teachers reported that their main source when deciding what to teach was the programme of work planned with the PSP for the second term.

Textbooks or other curricular material used to prepare for the lessons
The textbooks or curricular material besides the PSP activities teachers reported using to prepare for the first of their lessons observed (teachers were not always able to provide specific titles) included General Encyclopaedias; the Bible; 'a book that gave the Chinese version *of* Creation', World and Space (Childcraft:1974); Active Geography std 6 (Unit 4) by B. Podesta (De Jager & HAUM; 1985); Webster's Family Encyclopaedia (Arrow Trading:1994); World Book Encyclopaedia; 'Two books on Earth'; and Grade 7 Junior Atlas (NASOU, 1996).

Adverse factors affecting the school, the teacher, or the learners on the day their first lessons were observed
Six of teachers reported that there were no adverse factors affecting the school, themselves, or the learners on the day of the first lesson observations. Teacher 6 reported that there had been a burglary at the school the night before the lesson observation. As a result, he had not been able to organise lesson material/resources properly or photocopy the PSP activities for the learners before the researchers arrived. (The thieves had smashed the only photocopying machine at the school when they were trying to remove the machine.) On one of the days that Teacher 2 and 5's lessons were observed it was raining very heavily, the teachers felt this was the reason some of their learners were absent. Teacher 4 felt that learners in her class were inhibited by the presence of the researchers. In Teacher 8's lesson, other teachers/learners interrupted the teacher during the class on a number of occasions (for example, by bringing messages to the teacher).

6.2.1.2 Teachers' teaching strategies

Section 6.2.1.2 provides information on the 'outward forms' of teachers' teaching strategies, in terms of

- teachers' classroom organisation;

- the availability and use of text books and other material resources;
- the pace of the lesson;
- learner participation and involvement in the lesson;
- teachers' organisation of the classroom activities;
- the language(s) of learning

Classroom organisation

The researchers reported that teachers made use of:

- whole class teaching in twenty-one out of the twenty-two lessons observed;
- learners working in groups in fourteen of the twenty-two lessons observed.
- (Learners did not work in groups in eight of the lessons);
- learners working in pairs in thirteen of the twenty-two lessons observed. (In nine of the lessons learners did not work in pairs);
- learners working alone in three of the twenty--two lessons observed.

None of the teachers reported that they grouped learners according to ability or any other criteria.

The availability and use of textbooks and other material resources

According to researchers' reports:

- in fifteen of the twenty-two lessons one copy of the PSP activity was available per group of learners. In two lessons one copy of the activity was available per learner, and in two lessons one copy was available per pair of learners. In three lessons learners did not have copies of the activities;
- learners themselves used resources/apparatus in eighteen of the twenty-two lessons observed. In four lessons, learners did not use resources/apparatus themselves;
- in thirteen of the twenty-two lessons resources/apparatus were made available per group of learners. In three lessons resources/apparatus were available per pair of learners. In two lessons they were available per learner. In four lessons learners did not use resources/apparatus themselves;
- in eighteen of the twenty-two lessons observed, teachers used resources/apparatus to demonstrate to the whole class. None of the teachers used resources/apparatus to demonstrate to a group of learners at a time. In four lessons teachers did not use resources/apparatus to demonstrate;
- learners in fifteen of the lessons observed were able to see the teachers' demonstration. In three lessons only some learners were able to see the teacher's demonstration properly. Teachers in four lessons did not use resources/apparatus to demonstrate;
- all or most learners in twelve of the twenty-two lessons observed had the necessary writing equipment (pens, paper, etc.) for the lesson. In five lessons none or only some learners had the necessary writing equipment. In five lessons no writing equipment was required.

Lesson pace

Researchers reported that teachers in seventeen lessons paced their lessons efficiently and appropriately in terms of available time. In five of the lessons teachers did not pace their lessons efficiently.

Learner participation and involvement

The researchers reported that in twenty-one of the twenty-two lessons observed all or most of the learners participated actively in the lesson. In one lesson only some of the learners participated actively.

Organisation *of* the activities

In thirteen of the twenty-two lessons observed learners worked on the activities in pairs/groups with assistance from the teacher. In four lessons learners worked on the activities as a class with the teacher instructing the whole class. In two lessons learners worked individually without assistance from the teacher. In one lesson learners worked individually with assistance from the teacher. In one lesson learners worked as a class with learners responding to one another. In one lesson learners worked in pairs/groups without assistance from the teacher.

Language(s) *of* learning

Reports on the lessons observed revealed that:

- all the PSP activities used in the lessons were written in English;
- learners in seventeen of the twenty-two lessons completed or wrote their work in English. In three lessons learners used drawings and other representations only in their written work. Learners in two of the lessons did not write at all during the lessons;
- in fourteen of the lessons teachers instructed learners in English/Xhosa but mainly English. In seven of the lessons teachers instructed learners in English/Xhosa but mainly Xhosa. In one lesson the teacher instructed the learners in Xhosa;
- learners used English/Xhosa but mainly Xhosa in teacher-learner interactions in eight of the lessons. They used Xhosa or Xhosa with science terminology in English to interact with teachers in twelve of the lessons. In one lesson learners used English/Xhosa but mainly English in teacher-learner interactions;
- learners used Xhosa or Xhosa with Science terminology in English in learner-learner interactions in eighteen of the lessons observed. They used English/ Xhosa but mainly Xhosa in two of the lessons. (There was no learner-learner interaction in two of the lessons).

Summary

Data on the teaching strategies most frequently adopted by the sample of eleven teachers revealed that:

- teachers made use of group/paired work in most lessons, and they made use of whole class teaching as frequently;
- learners themselves did practical, hands-on work in most lessons, and teachers also performed demonstrations in most of the lessons;
- in most lessons learners worked on the activities in pairs/groups with assistance from the teacher;
- all or most of the learners participated actively in most of the lesson,
- teachers paced their lessons efficiently and appropriately in terms of available time in most lessons.
- learners were provided with opportunities to read, write and listen to English in , most of the lessons;

- learners used Xhosa or Xhosa with science terminology in English to interact with the teacher or with other learners in most lessons.

The data on the teachers' teaching strategies provides evidence of all the teachers' using PSP language-sensitive activity-based methodology in their Natural Sciences lessons.

6.2.2 Teachers' engagement of learners with Natural Sciences concepts, processes and language

This section provides information on the ways that teachers used the Learning Programme and its activities to mediate key scientific concepts, processes and language in their Natural Sciences lessons. In particular, the section provides information on teachers' use, of PSP's language-sensitive activity-based methodology to develop learners'

- cognitive academic proficiency;
- knowledge and understanding of scientific concepts and the process skills of science;
- interpersonal communication skills; and
- thinking, reading and writing skills.

Section 6.2.2 of this report provides information on the implemented curriculum in terms of:

- teachers' engagement of learners in terms of the criteria (see 6.2.2.1); and
- a summary of the researchers' overall rating and ranking of teachers' engagement of learners (see 6.2.2.2).

6.2.2.1 Teachers' engagement of learners in terms of the criteria

The quality of teachers engagement of learners with the knowledge (concepts, processes and language) to be learnt in the PSP Learning Programme/activities has been assessed in terms of the seven criteria which (together with their indicators) were formulated for use in Part II of the classroom observation instrument.

Data from the video recordings of teachers' lessons has been combined with data from the observation schedules to construct short descriptions of the lessons observed (see Appendix S) The descriptions provide interesting insights into teachers' implementation of the Learning Programme, and into qualitative differences between teachers' practices. Incidences of teachers implementing practices valued in terms of the criteria on the observation schedules are most evident in the 'vignettes' of the 6 lessons awarded ratings of 28 or more. (That is, lessons where teachers scored an average of at least 4 for each of the seven criterion). The following description of the most highly rated lesson, Teacher 9 's second lesson, illustrates this. (The overall rating for this lesson was 34. The 5 maximum score possible was 35.)

The classroom had a cupboard, usable chalkboard, a table for *the teacher, sufficient desks* for *the 46 learners, though slightly crowded, adequate lighting, ventilation and temperature and no outside distraction. The learners were arranged in groups of six. The learners worked individually without talking on an exercise written on the board. The exercise was in English.*

1. The sun's heat turns water into --------
2. Vapour-------, --------, and ------- forming ....
3. Water falls from ----------- as --------
4, The water collects in -------, --------, -------, and -------

The exercise was designed to assess whether they had-recalled and understood the previous day's lesson,, an introduction to the water cycle. When they had completed the exercise they exchanged papers and marked each others work. The teacher asked individual learners to read out the answers to the exercise.

On receiving the answers she probed further 'What happens to the water when the sun shines on it?' The following interaction took place.
Learner.ˉ It gets hot and turns into water vapour.
Teacher: Uteni why does vapour rise?
Learner.ˉ Because of ushushu (heat).
Teacher: Why ushushu?
Learner.ˉ Because of the sun.
Teacher Hot air rises. Why does it cool? Learner: It condenses.
Teacher: What do you mean by condenses?(learners' response in Xhosa).
Teacher Water falls from clouds as ....?
Learner: Precipitation
Teacher: Rain (The teacher writes `rain' in the space provided)
Teacher: Once it has collected in dams, what then?

In the second phase of the lesson the teacher asked the learners to do a drawing of the water cycle, in order to show their understanding. She insisted that they each do their own, and that they label the different parts of the drawing. The learners were all busy for about ten minutes drawing the Water Cycle. Most of the learners included all the components of the water cycle. In some cases the movement of the clouds was missing. When they had finished the drawing, the teacher asked the learners to put down their pencils. (Before they handed in their work She told the children not to change anything on their drawings, but to 'Be honest with yourselves. Do not change a thing.'

In the third phase of the lesson, a copy of the Water Cycle poster was given to each group with a set of questions and an envelope with coloured squares. The questions were colour-coded, for example 'Find places on the surface of the earth where there is water' was colour-coded blue. The children had to place the blue squares on their poster at the appropriate places. The teacher referred the learners to the big colour poster on the board if their black and white photocopies of the poster were not clear. Groups of children went up intermittently to investigate the details on the large poster.

The groups talked mainly in *Xhosa while doing this activity. The teacher moved from group to group clarifying points and asking questions concerning the task. The teacher assisted the learners in interpreting the poster by explaining how the picture showed a part of the earth cut away.*

This was the second of 3 lessons assigned to this activity. The teacher planned and paced the lesson very effectively, maintaining a balance between individual work, group work and whole class teaching. There was also time assigned to writing, drawing and speaking on the part of the learners.

Extracts from the descriptions of teachers' teaching have been used in the analysis that follows to identify obstacles to less proficient teachers implementing the practices valued in terms of each of the criterion used for the observation schedules.

Criterion 1 -Teachers' engagement of learners with the conceptual goals This section provides a summary, analysis and interpretation of the researchers' reports on the quality of teachers' engagement of learners with the conceptual goals of the activities.

Summary of researchers' reports

> *The data on teachers' engagement of learners with the concepts, processes and language to be learnt through the use of the activities provided evidence of teachers in 86% of the lessons engaging learners in understanding what was required, and in establishing a base for achieving the conceptual goals of the lesson. In 36% of the lessons teachers maintained the focus on the conceptual goals of the lesson (for example, by continually intervening to refocus learner's attention on the conceptual goals).*

In one (4.5%) of the twenty-two lessons observed, the teacher was given a rating of one because he/she did not engage learners in conceptualising (understanding and thinking about) the PSP activity (task). In other words, the teacher did not provide learners with assistance/guidance in achieving the goals of the activity.

In two (9%) of the lessons, teachers were given a rating of two for engaging learners in conceptualising (understanding and thinking about) the activity in inappropriate ways.

In eight (36%) of the lessons, teachers were given a rating of three for engaging learners in conceptualising the activity by focusing their attention on procedural issues (what they were expected to do) rather than on the conceptual goals of the activity. In other words, although teachers in these lessons provided learners with activity-related instructions, they did not use the activities in ways that made the conceptual content (scientific concepts/processes) to be developed in the activity evident to the learners.

In eleven (50%) of the lessons, teachers engaged learners in understanding what was required and established a base for achieving the conceptual goals of the lesson. However, in three (14%) of these lessons, teachers were given a rating of four for explaining procedural issues and making the conceptual goals explicit (i.e. explaining what learners were expected to do and learn), but not assisting them to maintain the conceptual focus of the activity.

In other words, as the lessons proceeded these teachers did not intervene sufficiently in orientating learners' thinking and behaviour towards achieving the conceptual goals of the activity. Instead teachers tended to direct learners' attention away from rather than towards the central conceptual goal(s) of the activities.

For example, by orientating their attention on the representation/models they were working on/with rather than on the relationship between the representations/models they were working on with and the science concepts/processes they were expected to learn.

In eight (36%) of the twenty-two lessons, teachers were given a rating of five for engaging learners in achieving the conceptual goals of the activity by:

- ✍ explaining procedural and conceptual issues (i.e. what they were expected to do and learn); and
- ✍ maintaining the conceptual focus *of* the activity by periodically orientating learners' thinking and behaviour towards achieving. the central conceptual goals. (see Appendix S, Teacher 1's second lesson.)

In other words, in eight lessons, teachers explained the purpose of the activity and then used questions, cues or-clues to assist learners in maintaining the focus on achieving the key conceptual goals of the activity. For example, by subtly directing or orientating learners towards relating significant information in the text(s)/representations they were expected to use as sources of information to the models/representations/tasks they were working on/with.

Analysis of constraints on teachers' practices

An analysis of the data on teachers' engagement of learners with the conceptual goals of the activities revealed that teachers:

- themselves were not always entirely clear about the conceptual goals of some of the activities;
- used some of the activities to try to achieve too many, goals instead of focusing on achieving few key/strategic goals;
- needed greater assistance in maintaining the conceptual focus and achieving the conceptual goals of the activities.

The following extract from the descriptions of one of the lessons observed provides an example of a teacher who did not appear entirely clear about the goals of the activity he was using, and who needed to be assisted more directly through the activity in achieving the learning goals of the activity. The description illustrates how, although the teacher completed the sequencing task based on text included with the Big Bang Activity, he did not use the task or text in ways that assisted the learners to achieve the stated goals of:

- understanding that all matter and energy in the known universe originated from a huge explosion (one event); and
- developing skills in reading

> *The teacher gives each group envelopes with text (based on the reading) to sequence, and the groups begin to work on the sequencing task. However, there is some confusion as some of the envelopes do not have all the strips of text, and others have duplicate copies. The teacher tries to sort out these problems. He tells the groups that the 'the order of their stories must be logical'. He also says, that at the end of the lesson, they will use their own words to tell how the universe began'.*
>
> *The learners complete the sequencing task in English, but use Xhosa to interact with each other. While they are busy the teacher reminds them frequently about how much time they have left to finish the task.*

After about ten minutes, he instructs a member of each group to write their 'story' on the chalkboard. Four learners write their group's answer ('story') on the board simultaneously. All of the texts are incorrectly/inappropriately sequenced to different degrees. For example, one response reads:
'This explosion is known as the Big Bang Because it was so hot an explosion happened
Our sun, Earth and our bodies are made of particles that came from the Big Bang
Because of the force of gravity, this matter formed clusters called galaxies
Even today these galaxies continue to move apart
Fifteen billion years ago matter and energy were concentrated in one place.'

The teacher tells the class that each group must read each of the responses on the board, 'so that we know which one is the right one.' He then asks them to check 'that everything is there, is the story full?' One group realises that they have left out a sentence, and the 'scribe' writes the 'missing' text onto the board. The teacher gives no other feedback

The lesson ends with the learners copying their group's version of the sequencing task into their science notebooks (they do not use their own words).

Although the learners completed the sequencing task, and the teacher 'covered' the activity, the teacher focused on procedural issues. He did not intervene sufficiently to ensure that learners achieved the learning goals of the activity.

The above description (together with data from other lessons) also suggests that activities need to be designed in ways that provide learners with opportunities to develop or practice using concepts, processes and skills such as sequencing in progressively difficult ways (for example, sequencing or comparing two pieces of information, then three pieces of information, then four or more pieces of information etc.)

The following extract from one of the descriptions of teachers teaching illustrates how the teacher's attempts to create an integrated and inclusive learning experience resulted in fragmentation of the learning goals because the teacher tried to achieve too many goals. In this lesson the teacher used the PSP activity number 6, 'My little piece of Earth'. According to the Learning Programme, the concepts to be learnt through the use of this activity are:

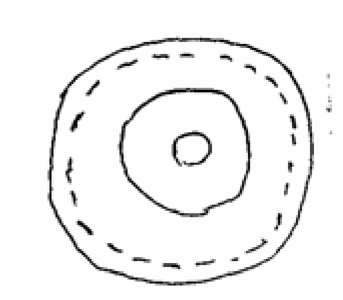
- the biosphere is where living organisms occur and interact with air, water, soil;
- up is away from the centre and down is towards the centre, gravity pulls things to the centre.

The key skills to be learnt are:

- Concluding;
- Patterns and relationships;
- Drawing, labelling and writing;
- Hypothesising.

However, because the teacher wanted to use the activity to integrate other concepts, he adapted the activity in ways that caused conceptual confusion amongst the learners.

Each learner had his/her own copy of the activity. The teacher introduced the lesson topic to the whole class and wrote 'My little piece of Earth' on the chalkboard. He told the learners, 'Today we are going to look at a piece of Earth,' and reminded them that they had already learnt about the shape and the different layers of Earth. He drew the following on the board to illustrate this.



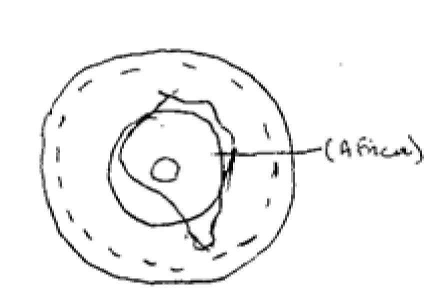
He pointed to the space between the solid and dotted lines and asked the class, 'What do we call this?' The class answered, 'The crust.' The teacher told them that he was going to focus on the Earth's crust. He told them he would give them a handout, and that they were to read the instructions and 'draw according to the instructions'. He said, 'Remember the shape of the Earth. When you draw a map - what colour is the land?' The learners replied, 'Brown.' He asked them what colour the water was. They answered that it was blue. The teacher said, 'Right, if you're drawing use green for vegetation like trees.'

He told them to use pencils to draw their pictures in their science books. He handed out the instructions for the activity but did not give them the photocopy of the piece of Earth; a crucial part of the activity (see Appendix P). He told the learners to work in pairs (in reality learners worked alone on their own drawings). He said, 'Look outside and see what is outside and draw as instructed. Use your imagination. You have 15 minutes for the drawing.' He instructed them to draw some grass and a person. He said, 'When you make a drawing, you start by making a title as I have done on the board. You can't just draw.'

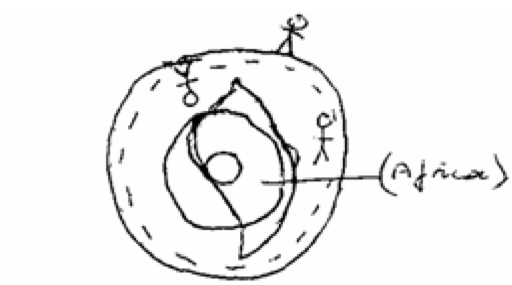
Some of the learners were confused because they did not understand the instructions written on the worksheet. The teacher told them to look outside and draw.' He then told the whole class to close their eyes. While their eyes were closed, he read them the instructions. He told them to imagine that they were at home, and to think of a tree, grass or lawn, and to imagine themselves standing outside. They had to imagine clouds and that it was raining. He told them to open their eyes and draw 'what I have told you.'

A learner asked the teacher 'How big must the house be?' The teacher told them that they have to 'draw big drawings'. Learners began to draw their 'everyday' drawings in their science notebooks. Some children used pens as they did not have pencils. They needed little assistance from the teacher as they now understood what they were expected to do The teacher told them that their drawings were not complete unless they were coloured in. However, very few learners had coloured crayons/pens. The teacher told them that they had five minutes left. When the learners objected, he gave them more time.

The learners took great pains over their drawings. The teacher complained that they 'have taken up the whole period for drawing and they are not finished yet.' He told them to stop drawing and said that they could finish their pictures later. He drew the following diagram on the chalkboard.



He told them to 'think about the layers of the Earth.The crust, the mantle and the core and then answer this question, Which way up are the people?' He used the same diagram to illustrate this and told the learners to refer to the diagram.



He reminded them that the Earth is round. A learner replied, Phezulu.' He drew stick figures on the surface of the 'Earth; one is facing 'down' and the other 'up' (as illustrated above). The learners said that the people were 'up'. He asked them 'How does the rain fall? Is it coming towards the centre?' A learner replied, 'It falls on all the countries.' (The were confused by his diagram which showed the inside and the continent of Africa outside of the Earfh on the same drawing. The teacher said, 'The Earth is not flat but round. We find water, grass, etc. on the crust of the Earth, where everything is growing. That is why Earth is precious. There are no trees on the core or mantle. The part of the crust where there is air, we call the biosphere.' The learners repeated the term 'biosphere'.

The teacher told the class that they also will learn about other layers. He asked them, 'what they know about the word No'? What is biology? What are they studying in Biology? He told them that it is 'the study of life' and that the layer that has life is the biosphere. The Earth is the only planet that has life and where you get air.' He used English and Xhosa but mainly English to instruct.

The description reveals that teachers need to be encouraged to focus on achieving fewer strategic goals rather than trying to provide learners with integrated and inclusive learning experiences.

The analysis of criterion 1 also reveals constraints raised by the needs of the activities themselves. Obstacles to achieving the conceptual goals of some of the activities included:

- limitations in resources both in terms of some of the teachers' personal knowledge/experience;
- limitations because learners either lacked foundational knowledge understandings and skills, or because they had not developed thorough understandings of the concepts/content covered in preceding activities;

- limitations in terms of the material and the equipment that the teachers had to draw on; and
- the large number of learners that some teachers had to support in their classes.

These constraints are illustrated in the following excerpt from the description of phase two of the first lesson described in this section. The second phase of the lessons consisted of the teacher's demonstration of the `Big Bang' to the class. To do this the teacher needed a pot, oil, popcorn and heat.

> *The teacher had intended to use the gas cooker used for the school feeding scheme. However, unfortunately when the class arrived at the 'kitchen; he discovered that the gas was finished. The class returned to the classroom while the teacher took about ten minutes to locate an electric hot plate.*
>
> *On his return the teacher placed the pot of oil on the hot plate. He told the class to come to the front of the classroom to watch the demonstration. All fifty five learners moved to the front of the classroom. Some learners had to clamber onto tables/desks to get a better view. Others were unable to see the pot at all as they had to stand at the back of the group. As the oil heated up, the teacher placed some of the popcorn into the pot, The group of learners perched on the desks lent forwards to see the pot, pushing against the learners who surrounded the pot of hot oil. Learners standing right at the back pushed forward in an attempt to see more clearly.*
>
> *Unfortunately the teacher had brought the wrong corn and the demonstration was unsuccessful as the corn `refused' to 'pop'. The teacher persevered with the corn for about ten - fifteen minutes before telling the learners, some of whom were beginning to show signs of boredom and were becoming disruptive, to return to their places.*

c=

Interpretation

The analysis of data on criterion 1 indicated that:

1. teachers did not always understand the difference between:
   - successfully completing an activity; and
   - using the activity to assist learners to understand particular concepts, processes and language.
2. if the conceptual goals of the Learning Programme are to be achieved, the learning material needs to be designed to provide learning experiences that:
   - are extremely focused on achieving a few strategic goals (rather than trying to provide learners with integrated learning experiences that are inclusive at the expense of achieving the key conceptual goals); and
   - address concepts/processes/skills in terms of incremental cognitive complexity, or that assist learners to use concepts/processes skills in progressively difficult ways.

3. if the conceptual focus of the activities is to be maintained, the core Natural Science knowledge (content, concepts, processes, and language including Natural science terms, definitions and vocabulary) to be learnt through the use of the activities needs to be made much more elicit (rather than embedded) in the activities and the curriculum material.

Criterion 2 - Teachers' engagement of learners with scientific procedures and processes

This section provides a summary, analysis and interpretation of the researchers' reports on the quality of teachers' engagement of learners in using their conceptual framework to develop some of the procedural understandings and process/thinking skills they need to think, communicate and work scientifically.

> *Summary of researchers' reports*
>
> *The data on teachers' engagement of learners with the concepts, processes and language to be learnt through the use of the activities provided evidence teachers in 72% of lessons assisting learners to develop some procedural understandings and process skills. In 4.5% of the lessons teachers used the activities to ask questions that required learners to ask questions for themselves.*

Teachers in three (13.5%) of the twenty-two lessons observed were given a rating of one. Teachers in these lessons did not use the PSP activity to engage learners in developing any of the procedural understandings and process skills they need to think, work and communicate scientifically. In other words, teacher questioning in these lessons required little if any thought other than simple recall from the learners.

In three (13.5%) of the lessons, teachers were given a rating of two for using the PSP activity to engage learners in surface/external forms of the process skills. For example, by asking them to 'predict' or 'estimate' but not assisting them to use available information as well as their prior knowledge to give reasoned responses. In other words, teachers in these lessons used low-level questioning that did not assist learners to use their own conceptual frameworks.

Teachers in seven (31.5%) of the lessons were given a rating of three. These teachers used the PSP activity to engage learners in using their conceptual framework to develop some of the procedural understandings and process skills they need to think and work scientifically by asking them questions that required them to make links/connections between objects/events/ideas. For example, by asking them questions that engaged them in using their senses and available information to observe/look for and identify pattern/properties/characteristics! similarities and differences, and make comparisons. Teachers in these lessons tried to assist learners to link their prior learning and experience of everyday life to the new science concepts. However, in these lessons teachers did not ask questions that required learners to:

- justify their answers/thinking/conclusions; or
- ask questions for themselves.

Teachers in eight (36%) of the lessons were given a rating of four. Teachers in these lessons used the PSP activity to engage learners in using their conceptual framework to develop some of the procedural understandings and process skills they need to think and work scientifically by asking them questions that required them to:

- make links/connections between objects/events/ideas; and

- justify (give reasons for) their answers/thinking/conclusions.

Teachers in these lessons asked learners to explain their answers and the reasoning they used. In other words, in these lessons teachers were using the PSP activities to establish a basis for developing some procedural understandings and process skills, but were not using the activities to ask questions that required learners to ask questions for themselves. (see Appendix S, Teacher 3's first lesson.)

In one of the twenty-two lessons observed (4.5%), the teacher was given a rating of five. In this lesson the teacher used the PSP activity to engage learners in using their conceptual framework to develop some of the procedural understandings and process skills they need to think, communicate, and work scientifically (i.e. the skills and understandings needed for investigating) by asking questions that required them to:

- make links/connections between objects/event/ideas;
- justify their answers/thinking/conclusions; and
- ask questions for themselves (for example, by asking questions that generate questions from the learners about the concepts being explored).

Analysis of constraints on teachers' teaching

An analysis of the data on teachers' engagement of learners with higher level thinking/process skills revealed evidence of teachers:

- having difficulty in moving learners towards a higher level of understanding/ thinking when they were not entirely in control of the subject matter that they were trying to teach;
- not using unusual/novel/incongruous situations as opportunities to adopt a more process-orientated approach to teaching.

The following description taken from one of Teacher 8's lessons illustrates a 'missed opportunity' to move learners towards a higher level of understanding/ thinking. The teacher is using Activity 4, 'The Solar System'. One of the conceptual goals of this activity is for learners to understand that 'different planets have different characteristics'. A key skill to be learnt is that of reading a data table.

> *When the class gets to the question about the hottest planet, the learners say that the answer is Mercury. The teacher asks them why they think this, and the class reply that it is because Mercury is the closest planet to the sun. The teacher tells them to refer to the information chart (data table) on their worksheets. She says they must use the chart to check which planet has 'more degrees Celsius' by looking at the column headed 'temperature'. She explains what is meant by 'maximum' and 'minimum' temperature.*
>
> *She tells the class that `according to the distance from the sun, Mercury is the hottest because it is the closest, but if you look at your information sheet, you'll see that Venus is the hottest. If you have a heater on, then the person sitting closest to the heater gets the most heat.' She tells the class she does not know why (according to the table) Venus is the hottest and asks the researchers if they know why this is so.*

The excerpt provides an example of a situation where learners' existing conceptual framework (and the teacher's knowledge of the subject matter) was inadequate for providing an explanation. The teacher could have used this as an opportunity for moving them to a higher level of understanding and thinking by getting them to try to formulate an alternative explanation/hypothesis. However, the extract shows that, for the teacher to successfully adopt a more process orientated approach to teaching and move learners towards a higher level of understanding or thinking, she herself had to have essential content/discipline knowledge.

The extract that follows is from a description of a lesson where a different teacher, Teacher 3, is using the same activity, Activity 4. The description illustrates the difference that the teacher's knowledge of the subject matter made in terms of the teacher's capacity to spontaneously meet the content needs of the learners as they arose. However, the extract also illustrates that teachers did not always use these situations to provide learners with opportunities to generate questions themselves or to propose their own hypotheses or explanations (in other words, to develop scientific processes).

> *The teacher asks the class to name the planets that are the furthest and nearest from the sun. He asks them which planet 'should be' the hottest planet. One of the learners says it is Mars. He asks the learner why he says this. The learner cannot explain so the teacher says, `Look here is the sun and we know that the sun is a big hot star and that is where we all get our heat from. If the sun is so hot, which planet will be the hottest? The learner says, 'Mercury'. The teacher says, `It stands to reason that it should be Mercury but is it really Mercury? 'Some learners call out, 'no.' The teacher asks them to tell him which planet is the hottest and the learners reply that it is Venus (they have noted this from the data table). The teacher explains the reason for this. He says that 'all the planets are spherical like the Earth. This means that they all have to have an equator somewhere here' (points to the 'middle' of a planet). It is said that Mercury is very hot there, but at the poles it is very cold, so it is unlike Venus where it is extremely hot everywhere.'*

The extract suggests that teachers need assistance in making stronger cognitive demands on their learners through the types of questions included in the learning material.

Interpretation

The analysis of criterion 2 suggests that teachers need additional help:

1. through curriculum material that takes into account the depth and breadth of teachers' current subject knowledge and helps to `bridge' the gap between their inadequate subject matter knowledge and the needs of the curriculum by mediating the necessary subject matter on behalf of the teacher;

2. through INSET directed at developing teachers' own discipline knowledge and understanding so that they are able to engage learners more spontaneously with content (concepts, processes and language) at higher levels of thinking and understanding;

teachers need assistance in moving learners towards a higher level of understanding/thinking through

- the use of unusual/hypothetical/incongruous situations where learners' existing conceptual frameworks are in conflict with or inadequate for solving problems or explaining the situations; and
- the inclusion of more open-ended questions cleverly formulated both to challenge learners' current thinking and to impel learners to generate questions themselves, or to propose alternative hypotheses or explanations that can be used to solve problems and explain unusual/ egregious phenomena or theoretical situations.

Criterion 3 - Teachers' engagement of learners in expressing their understandings of the Natural Sciences concepts

This section provides a summary, analysis and interpretation of the researchers' reports on the quality of teachers' engagement of learners in expressing their conceptions (understandings) of the Natural Sciences concepts to be learnt through multiple modes in their primary language and the language of learning.

Summary of researchers' reports

The data on teachers' engagement of learners with the concepts, processes and language to be learnt through the use of the activities provided evidence of teachers in 49.5% of the lessons:

- *providing learners with opportunities to use their primary language and the language of learning to express their everyday understandings of the science concepts, and*
- *providing learners with opportunities to use scientific modes of communication (for example diagrams with labels).*

Teachers in 4.5% of the lessons provided learners with sufficient assistance in converting, re-interpreting or `restructuring' expressions of scientific conceptions/ knowledge/experience into more abstract/indirect/symbolic scientific modes of communication/ representations. (See Appendix S, Teacher 5's first lesson.)

In one lesson (4.5%) the teacher was given a rating of one because she/he did not use the PSP activity to engage learners in expressing their conceptions of the Natural Sciences concepts to be learnt.

In three lessons (13.5%), teachers were given a rating of two. Teachers used the activity to engage learners in expressing their everyday conceptions of the concepts to be learnt through everyday modes of communication (speaking, writing) in their primary language. They did not engage learners in using scientific modes of communication and language.

In seven (31.5%) *of* the twenty-two lessons, *teachers were* given a rating of three. Teachers used the PSP activity to engage learners in expressing their conceptions *of* the concepts to be learnt through everyday modes of communication (speaking, writing, drawing) in their primary language and the language *of* learning, but did not engage learners in using scientific modes *of* communication and language.

In ten (45%) of the lessons, teachers were given a rating of four. Teachers used the PSP activity to engage learners in expressing their conceptions of the Natural Sciences concepts to be learnt through everyday modes of communication in their primary language and in the language of learning. Teachers also engaged learners in using scientific modes of communication and language. However, in these lessons, teachers did not engage learners in using their own expressions of their understandings (particularly as expressed in their primary language) together with scientific modes of communication and language as tools for: extending and formalising their own repertoire of scientific language and modes of communication;

- consolidating and `sorting out' their everyday and scientific conceptions; and
- building on and moving beyond their existing understandings of the science concepts.

In one (4.5%) of the twenty-two lessons observed, the teacher was given a rating of five. The teacher used the- PSP activity to:

- engage learners in expressing their everyday and scientific conceptions (understandings) of the science concepts to be learnt through multiple modes in the language of learning and their primary language; and
- use learners' expressions of their conceptions (particularly as expressed in their primary language) together with scientific modes of communication and language (e.g. diagrams with labels, charts, tables, indirectiabstract models, etc.) as tools for:
    1. extending and formalising their own repertoire of science language and modes of communication;
    2. consolidating and 'sorting out' their everyday and scientific conceptions; and
    3. building on and moving beyond their existing understandings of the science concepts.

Analysis of constraints on teachers' teaching

An analysis of the data on teachers' engagement of learners in expressing their conceptions of the Natural Sciences concepts to be learnt through multiple modes reveals that some teachers did not pay adequate attention to ensuring that learners understood the relationship between the representations/models they were working on/with, and the science concepts they were expected to learn.

The following extract from the description of one of Teacher 4's lessons illustrates this quite clearly. The teacher is using the 'Big Bang' Activity. The conceptual goal of this activity is for learners to understand that all matter and energy in the known universe originated from a huge explosion (one event). The key skills to be developed are reading, drawing, and 'imaging'.

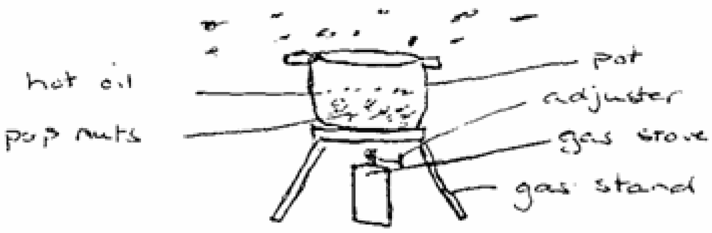
The teacher has placed a pot of oil on top of a gas burner on her table at the front of the class. She tells the class that she is going to use popcorn to demonstrate the (Big Bang) 'explosion'. All the learners are able to see the 'demonstration' clearly. She places some popcorn into the oil, which is not quite hot enough (there is no door to the classroom and there is a strong draft coming through the open doorway). The popcorn 'explodes' very slowly. As individual pieces of popcorn pop out of the pot, the teacher tells the class that they must 'observe what happens' because they are 'going to draw' and label what you have seen'.

The teacher says, 'Can you see that fat also splashes out, there are big pieces of popcorn and small pieces of fat. That is how it happened. But the popcorn cools down quickly because these are just small bits. So it isn't exactly like the Big Bang. Because (in the Big Bang) big pieces came out and they took a long time to cool down. That is why, even now our Earth is still very hot inside.'

She hands out some of the popped corn and asks the class if they 'can see that not all the popcorn is the same shape. Not all the pieces came out the same shape. This is why our Earth has mountains and rivers.'

She tells the class that they must begin their drawings. They must 'draw what happened, draw the Big Bang.' She points to the pot and says, 'This is the energy that exploded. Draw and label exactly.' She tells them, 'Yesterday we talked about the Big Bang and today we saw it happen.' She says that they have five minutes to complete the task, and that 'this is the model, draw what happened'. 'If they don't have a drawing, they will get zero.' They must 'show where energy is and where all the bits and pieces are.' They must draw their 'own interpretation and not copy from each other.' Learners work individually on the task without assistance from the teacher. They pay careful attention to the details and labels. All the learners work very conscientiously to complete the task.

The following is a typical example of learners' efforts (all the learners write their labels in English).



At the end of the lesson, the teacher collects their work for marking.

The teacher does not provide adequate assistance to the learners to move beyond their naive realist conception of the model, or to understand the relationship and difference between the model and the concept of the 'Big Bang'. As a result, the model rather than the concept has become the learning goal.

Interpretation

The analysis of criterion 3 indicates that teachers needed additional assistance in:

1. providing learners with more direct support in converting/reformulating/re-interpreting expressions or realist models of scientific conceptions/knowledge

into more abstract/indirect/symbolic scientific modes of communication/ representations; and

2. ensuring that the learners understood the relationship and differences between the representations/models they were working on/with and the Natural Sciences concepts they were expected to learn.

Criterion 4 - Teachers' engagement of learners with new science discourse/language

This section provides a summary, analysis and interpretation of the researchers' reports on the quality of teachers' engagement of learners with the new/additional discourse they need to think about, work with, and communicate their understandings of the new Natural Sciences concepts.

Summary of researchers' reports

The data on teachers' engagement of learners with the concepts, processes and language to be learnt through the use of the activities provided evidence of teachers in 72% of lessons providing learners with appropriate and correct newladditional discourse, and in focusing on meaning rather than form. In 4.5% of lessons teachers assisted them to understand differences between their everyday language/concepts/knowledge and new science language/ concepts/knowledge.

In two (9%) of the lessons, the teachers were given ratings of two, Teachers did not use the PSP activity to engage learners with the new/additional discourse they need to think about, work with, and communicate their understandings of the new concepts to be learnt.

In two (9%) of the lessons, the teachers were given ratings of two because they used the activities to engage learners with inappropriate/incorrect discourse in relation to the new concepts to be learnt.

In two (9%) of the lessons, teachers were given ratings of three. In these lessons, teachers used the PSP activity to engage learners with appropriate and correct new/additional discourse, but focused on form rather than meaning. For example, by involving learners in repeating new science language, but not using links between related everyday language and the new science language to assist learners to understand the new science concepts/language.

In fifteen (67.5%) of the lessons observed, teachers were given ratings of four. They used the PSP activity to engage learners with appropriate and correct new/additional discourse to think about, work with, and communicate their understanding of the new concepts to be learnt. Teachers engaged learners in focusing on meaning rather than form by using links/connections/relationships between related everyday and/or scientific conceptions/language in their primary language and the language of learning and the new concepts to be learnt. In other words, teachers related the subject matter to things that learners already knew, either to their real life experiences or to their previous school learning. These teachers did not use differences between learners' everyday and/or scientific conceptions/language/discourse to assist learners' to understand the new concepts/language. For example, by using differences between learners' ‘out of school' discourse and the new science discourse to assist learners to understand differences between their everyday conceptions/language and the Natural Sciences concepts/language to be learnt. (See Appendix S, Teacher 5's first lesson.)

In one (4.5%) of the lessons observed, the teacher was given a rating of five for using the PSP activity to engage learners with appropriate and correct new/additional discourse, and in focusing on meaning rather than form by using:

- links/connections/relationships between related everyday and/or scientific conceptions/language in their primary language and the language of learning and the new concepts to be learnt; and
- differences between learners' everyday and/or scientific conceptions/ language/discourse to assist learners' to understand the new concepts. For example, making differences between everyday English and Xhosa words and concepts, and words and concepts that have a particular scientific meaning or purpose explicit.

Analysis of constraints on teachers' teaching

An analysis of data on teachers' engagement of learners with the new/additional discourse indicated that most of the teachers needed assistance in making the differences between learners' everyday and/or scientific conceptions/language/ discourse explicit.

In the following extract from one of the descriptions of the teachers' lessons, the teacher is using Activity 8, 'Travelling to outer space'. The conceptual goals of the activity are for learners to understand that:

- rockets are propelled by gases being pulled out the back;
- to leave the Earth you have to overcome the force of gravity;
- you have to take oxygen with you to outer space - to burn rocket fuel, and to breathe.

The description of the classroom interaction illustrates how, by not making differences between learners' everyday understandings and general use of the word 'travel' and the more scientific conception of 'space travel' explicit, the teacher 'blocks' rather than assists learners to understand differences between their everyday understandings, experiences and language and science concepts to be learnt.

> *Teacher 1 used whole class teaching to introduce the activity to the class. He started the lesson by saying, 'We say that the Earth is round' and then asked the class 'what they would have to do before they would be able to see that the Earth is round'. A learner responded that they would have to go 'high up' to see this. The teacher asked them what they would have to do to go into space. A learner replied, 'a rocket' (in English).*
>
> *The teacher asked the class what they would have to take with them if they travelled into 'outer space'. He wrote OUTER SPACE on the chalkboard. He said, 'There's a lot you can take- perhaps if you're going to travel to Gauteng...' The class called out suggestions and the teacher wrote every suggestion on the chalkboard. One learner suggested 'goods'. Another suggested 'oxygen' and another, 'water.*

The teacher told them that they would need water 'in case they became thirsty.' Other suggestions included 'clothes', 'bags', 'blankets', 'a watch', 'a torch' and 'towels',

When one of the learners suggested that they take tools, the teacher asked him what they needed tools for. The learner said, 'to look at the weather.' Another learner suggested that they would need a compass. When the teacher asked her why, she replied 'for direction'. Someone else suggested that they needed a microscope 'to see small things that you cannot see with your eyes'.

Analysis of the data also provided evidence of teachers needing greater assistance in providing learners with appropriate and correct science vocabulary, terms and definitions in their own classroom teaching. For example, in the following extract from one of the lessons, the teacher used the 'Sun and its family' Activity. The conceptual goals of the activity are to develop an understanding that:

- the sun and its family of planets forms an organised system;
- planets move in fixed orbits around the sun;
- different planets have different characteristics; and
- rotation (on own axis) and revolution (around the sun).

The description of the classroom interaction illustrates the role that classroom texts need to play in mediating scientific language (as well as subject knowledge) through the provision of clear definitions and explanations of scientific terms/ concepts such as 'gravity', as well as related terms such as 'floating'.

After the class has read the next paragraph of the text aloud together, the teacher says, We talk about the Earth, the sun and other planets as the family of the sun. Can you tell me what we are learning about or what we have learnt from this piece of paper?' A learner replies, 'We have learnt about the sun, the stars and the Earth and planets,'

Another learner says, 'We learnt that there are nine planets.' Another says, 'The sun is also a ball that floats.' The teacher asks the class what 'floats' means. She says, 'is it standing still or is it moving.' One learner says it is 'standing'. Another says that it is 'moving'. The teacher asks the learners to demonstrate what he means. The learner moves her arms across to demonstrate what she means.

The teacher says, 'if it is floating, it means that there must be something suspended onto it. There must be something that is holding it so that it cannot fall. If you take a plastic ball then that ball is going to float and not go down because the water suspends it. Why is our Earth not falling down into pieces? What is keeping the Earth floating? The class tell her that it is the force of gravity. She writes FORCE OF GRAVITY on the chalkboard.

The analysis of teachers' engagement of learners with the new science discourse also revealed that teachers need assistance with:

- paying careful attention to how concepts are presented and developed through the language used in their teaching; and
- establishing whether related foundational language and understandings/ conceptions are in place.

For example, the following extract from the description from one of the observed lessons illustrates ways in which conceptual confusion can arise from the language that is used by the teacher and learners. The description also provides evidence of teachers experiencing difficulty in using activities to engage learners with concepts/language at appropriate levels. This was because not all the learners had developed the related foundational conceptual understandings and language that they were supposed to have developed earlier on in the Learning Programme (through the use of preceding activities).

The teacher is using the PSP activity number 6, 'My little piece of Earth'. The conceptual goals of the activity are that learners understand that:

- the biosphere is where living organisms occur and interact with air, water and soil; and
- up is away from the centre, down is towards the centre, gravity pulls things to the centre.

The teacher has already covered the 'Inside of the Earth' Activity (where learners learnt about the layers of the Earth) and the 'Solar System' Activity (where learners learnt about the Earth rotating on its own axis and revolving around the sun).

The description of the classroom interaction provides examples of the kinds of confusion that can arise from the use of the scientific terms 'revolve' and 'rotate' in the language of learning (English) and the use of the Xhosa word 'jikeleza', one word that is used to describe the two different and difficult concepts. Furthermore, some learners do not have a thorough conceptual understanding of the 'Earth's crust', another concept that they were supposed to have developed earlier on in the Programme. (They may have been confused by their common sense understanding/experience of the 'crust' on bread as their understanding appears to be that the crust is an outside layer that 'contains' everything below and on the surface Earth).

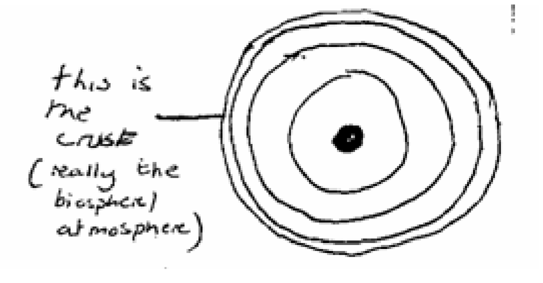
The teacher starts the lesson by referring the class to the worksheets he has given them. He reads and explains the instructions for the activity, 'My little piece of Earth', to the class. He checks that the class understands exactly where they must do their drawings on their worksheets, and asks learners to show him where on the diagram they are going to draw their pictures. Various learners show this to him.

The children start to do their drawings. The teacher tells them they are going to cut out their 'pieces of Earth' and 'make a whole Earth'. He reminds them that the 'Earth is spherical'. When most of the class has finished drawing, he shows them how to tear/cut their worksheets so that each learner has a piece of Earth.' When the learners have completed their drawing and cut their paper, they take their work to the teacher who pastes each learner's efforts onto a piece of cardboard with Prestik. When all the pieces are in place, the teacher puts the sheet of cardboard (with all the pieces of Earth' forming a circle representing the Earth) on the chalkboard.

He tells the learners to look at the board saying that they 'can see the Earth is round - here are the people's houses, clouds and so on. This place is called the biosphere.' He writes this word on the chalkboard. He tells the class that 'everything alive lives there. Outside the biosphere is the atmosphere.' He then refers them to Question 5 on their worksheet. This is a question that has been added to the activity by the teacher. The teacher draws the following diagram on the chalkboard.

The learners have to draw and label the layers of the Earth (crust, inner and outer core etc.) as well as the biosphere and atmosphere. The teacher tells them to work in groups. He says that, when they are ready, a representative from each group has to come up to the board and tell the rest of the class where the group has decided to place their labels. The learners use Xhosa to interact with one other.

After a while, the teacher invites a member of the first group to come up to the chalkboard to show everyone what his group has decided. The learner points to the drawing and says:



The teacher does not comment but asks the representatives from the second and third groups to show the class what they think. These learners correctly indicate that the crust is beneath the biosphere. Group 4 indicates that they also think that the crust is on the outside of the biosphere and atmosphere. Learners use mainly Xhosa in teacher-learner interactions. The teacher explains that 'the crust is part of the biosphere' and shows the class where the labels should go. He uses English/Xhosa but mainly Xhosa to instruct.

He tells them that they must write the answers to all the questions on their worksheets in their books. Before they do this he reads each question out aloud to the class. The learners begin to write their answers into their books. He tells them to note the difference between the words 'of and 'off' in the question 'Why does everything not fall off the Earth.'

There is a class discussion around this question. One learner suggests that it is because 'the Earth is stable (uphansi) and not slanting to one side and that that is why nothing falls off.' The teacher says, 'Yes, Earth is on its own axis and it rotates on its axis but ...' He demonstrates with his hands that it is tilted to one side. The teacher again asks the class to explain why We don't fall off?' He holds the cardboard with the pieces of Earth' arranged in a circle and 'turns' the Earth to demonstrate the Earth rotating.

Another learner suggests that We don't fall off because the Earth rotates but the houses are actually stationary. They are standing still and only the Earth is rotating. Someone else says that 'the Earth is rotating and it is nearer the sun and the sun holds the Earth in place. The teacher says, 'the sun is pulling the Earth, what about the houses on Earth?' The learner says, 'they are held in place by the Earth.' The teacher says, 'So the gravity of the sun is also pulling the houses.' The learner looks doubtful but replies, Yes.'

Another learner says, 'The crust is holding the houses.' He goes to the chalkboard and indicates that the crust is outside the atmosphere. The teacher tells him that 'the crust is part of the Earth'. Another learner comments that, 'Some houses do collapse (ziyawa) due to heavy wind.' The class laugh.

The teacher refers the class to the 'pieces of Earth' drawings on the cardboard. He points to the section (biosphere) where the animals, houses and people are, he tries to explain that 'above is up' regardless of your position on the planet. He takes a chalkboard duster and drops it. He says, even if we're in *the air, we don't fall off.' One of the learners uses his notebook to try to demonstrate how the Earth is steady (the position is the same) although it is moving. The teacher tells him to rather use one of the paper mache globes' they had made in a previous lesson to demonstrate this. The teacher shows them how, even though 'South Africa is on the side we don't fall off.*

A learner says that this is, 'because the mass/weight (The Xhosa word for 'mass' and 'weight' is 'ubunzima) of the Earth is less than that of the sun. Because the sun has greater mass/weight, it is holding the Earth. A person's weight/mass is not equal to the mass of the Earth hence the people don't fall off.' The teacher asks the learner, 'If I walk on the roof, won't I fall off?' He asks them to tell him why he would fall off. A learner says, 'because your weight/mass is greater than the weight/mass up there.' Someone else says that because your weight/mass is not on the roof but beneath the roof.'

Another learner tries to use his notebook to demonstrate his understanding. The teacher gives him one of the models of the Earth to use instead. He shows the Earth revolving (the word jikeleza is used for both terms in Xhosa) and asks, 'why does the sun rise on one side and set on the other - why doesn't the sun jikeleza" as well?' The teacher tells the class he needs to correct something. Firstly the sun does not revolve (jikeleza) but the Earth revolves around the sun (he uses the English word 'revolve). Secondly the Earth rotates (he uses the English word 'rotate). He demonstrates how the Earth revolves around the sun and rotates at the same time.

The teacher returns to the original question, 'why don't we fall off?' Someone says that it 'is as if the Earth has a magnet.' The teacher writes 'force of gravity' on the chalkboard.

(Note: This is one of the lessons that went way beyond the time allocated).

The analysis revealed that teachers need to be assisted in paying careful attention to the conceptual confusion arising through differences between learner's everyday (primary) language, the language of learning (English), and the new Science language.

The following extract of a classroom interaction provides evidence of a teacher focusing on meaning rather than form and illustrates how the language used in the texts and activities, and the teachers' efforts to 'close the gap' between learners' everyday understandings/language and scientific conceptions of terms such as 'concentration'; 'clusters'; and 'explosion' could cause conceptual confusion or result in fragmented understandings of these concepts and the key concepts being taught.

The teacher refers the class to the text that they have just read and asks them what the word 'concentration' means. She asks them to give her an example of something that is concentrated. A learner says, 'Things that are in the same position.' The teacher asks, Are children who are seated together concentrated?' Another learner says 'Something clinging or clustered together.' The teacher tells them to think about condensed milk.

She asks them, 'If you are thirsty, can you take it out of the fridge and drink it? They say `no' and she asks them 'why not'. A learner says, `too sweet or too strong.' The teacher asks them, 'How could you quench your thirst with condensed milk? A leamer says in Xhosa that you need something to dilute (ukuxhuba) it.

She returns to the text and reads, 'it was very hot in this place where matter and energy was concentrated.' The teacher tries to demonstrate this concept by making some of the children crowd together so that they are squashed together. She says that, because they are `clustered together there is 'a lot of energy or a concentration of energy. Because it was so hot an explosion occurred and this explosion had a very big sound - what is it called?' A child says, Bang.' She says, `If one person moves from the group (referring to the learners squashed together in a group) an explosion would have occurred.'

She asks the class to explain 'what gravity does?' A learner says, 'Pull' in English. The teacher says 'Pull towards ....' She reads `Matter formed clusters' from the text and asks them to explain 'clusters'. She reminds them about peanut clusters' which she says consist of a 'mixture of peanuts and chocolate.' She asks them. 'What are the clusters in space called?' A learner says, galaxies.' The teacher tells the class that `galaxies keep moving away from the centre while the centre is pulling them.' She asks them why the `centre is pulling?' A learner says, Because of the force of gravity.'

The analysis shows that curriculum designers/materials developers need to pay very careful attention to the kinds of language used in the texts and activities provided. In particular, attention needs to be paid to anticipating the ways in which conceptual confusion can result through teachers' use of everyday metaphors used in an effort to 'close the gap' between learners' existing understandings and the scientific conceptions described in the texts.

Interpretation

The analysis of criterion 4 indicates that teachers needed greater assistance in:

1. using differences between learners' everyday and/or scientific conceptions/ language/discourse to assist learners' to understand the new concepts/ language. In other words, assistance in using differences between learners' 'out of school' discourse and the new science discourse to assist learners to understand differences between their everyday conceptions/language and the science concepts/language to be learnt;
2. establishing whether the related foundational language and understandings/ conceptions that should have been learnt in preceding activities/lessons/ grades are in place so that they are able to 'build' cumulatively on the skills/knowledge already learnt;
3. providing learners with appropriate, correct and clearly-defined science vocabulary, terms and definitions; and
4. paying much more careful attention to how concepts are presented and developed in the language used in their teaching. In particular, paying attention to the ways in which conceptual confusion can result
    - from the use of everyday metaphors used in an effort to 'close the gap' between learners everyday understandings and scientific conceptions; and
    - through differences between learner's everyday (primary) language, the language of learning (English), and the new Science language.

Criterion 5 - Teachers' engagement of learners in learner-learner interaction

This section provides a summary, analysis and interpretation of the researchers' reports on the quality of teachers' engagement of learners in learner-learner interaction about the concepts to be learnt.

> *Summary of researchers' reports*
>
> *The data on teachers' engagement of learners with the concepts, processes and language to be learnt through the use of the activities provided evidence of teachers in 68% of the lessons engaging learners in learner-learner interaction about the science concepts to be learnt in ways that could benefit their thinking/discourse. In 18% of the lessons, teachers used whole class discussions to assist learners to develop the strategies they needed to solve problems/work collaboratively in groups. (See Appendix S, Teacher Ts second lesson.)*

In four (18%) of the twenty-two lessons, teachers were given ratings of one. Teachers did not use the activity to engage learners in any learner-learner interaction.

In one lesson (4.5%) the teacher was given a rating of two for using the activity to engage learners in learner-learner interaction but mismanaged the interaction. For example, by organising group work where there were too many learners in each group for learners to interact and work together effectively.

In two lessons (9%) the teachers were given a rating of three. The teachers used the activity to engage learners in learner-learner interaction by providing them with opportunities to interact through correcting each other's errors and through helping one another. However, teachers did not engage learners in learner-learner interaction in ways that they could benefit from each other's thinking/ discourse (in other words, for it to contribute to improvement in learners' understandings, knowledge and skills).

In eleven lessons (50%) teachers were given ratings of four. Teachers used the activity to engage learners in learner-learner interaction about the science concepts to be learnt in ways that:

- encouraged them to correct each other's errors and to help one another;
- they could benefit from each other's thinking/discourse.

However, the teachers in these lessons did not assist learners to develop the skills they need to work and solve problems collaboratively. For example, how to share ideas, how to listen to one another, how to negotiate, how to explain their thinking, how to evaluate each other's method, etc.

In four (18%) of the lessons observed, teachers were given ratings of five. Teachers used the PSP activity to engage learners in learner-learner interaction about the science concepts to be learnt in ways that:

- encouraged them to correct each other's errors and to help one another;
- they could benefit from each other's thinking/discourse. For example, by organising discussion in ways that generate discussion and involve learners in

discussing ideas and sharing skills, in explaining their thinking to one another, etc.; and

- assisted them to develop the skills they need to work and solve problems collaboratively.

Analysis of constraints *on* teachers' teaching

An analysis of the data on teachers' engagement of learners in learner-learner interactions about the concepts to be developed raised questions about whether it is realistic for teachers who have large numbers of learners in their classes who need support to use group work to facilitate learner-learner interaction.

The following excerpt from one of Teacher 10's lessons illustrates the time it took for teachers who had large numbers of learners in their classes to provide each group with the opportunity to report back on the thinking and understanding of the learners in the group.

There were 66 learners in this particular class. The teacher had another Grade 7 Natural Science teacher assisting him. The learners had completed the first phase of the lesson where they finished drawing their 'little piece of Earth'. The teacher had placed a large piece of cardboard with learners' 'pieces of Earth' glued onto the cardboard on the chalkboard.

> *The teacher reads the class the questions on their worksheet. He holds up the 'Earth' (the cardboard with the pieces' stuck forming a circle). He says, 'If you look here you'll see that we have all these pieces of Earth and that the Earth is spherical.' He points to the area that represents the biosphere and writes the word BIOSPHERE' on the chalkboard. He says, 'You have drawn a person, clouds, houses, plants, animals, rain in the biosphere, the place where all things interact. It is where life is. It is only a small place whereas the Earth itself is big.'*
>
> *He refers them to Question 5, 'Draw and label the Earth's layers (inner/outer core, mantle, crust), a question that the teacher has 'added' to the original activity. He tells the groups to discuss how you will go about labelling and showing the different layers.' The learners take time discussing this, and after quite some time, the teacher calls a representative from each of the groups to come to the front and show the class what their group has decided.*
>
> *This takes a very long time because the class is large and there are about 11 groups. The teacher does not correct learners' misconceptions as they arise, but waits until each group has had the opportunity to report on their conclusions (thinking and understanding). A number of groups indicate that the 'crust' of the Earth is on the outside of the biosphere. One group indicates that they think that the 'mantle' is the crust. (This was knowledge that they should have gained through preceding activities.)*
>
> *After about half and hour, when all the groups have reported back, the teacher reviews their answers. He asks the class to tell/show him where the atmosphere and biosphere are. At first no one responds. Then one learner says, 'The atmosphere is where people are.' The teacher repeats this statement as a question. Another learner says that 'The biosphere is where the people are and the atmosphere is above the biosphere.'*

The teacher explains, 'The atmosphere is where there is surrounding air. The biosphere is where people, animals, plants etc. live. There is life in the biosphere. Someone said this is the crust (he points to the line marking the end' of the atmosphere). Remember there are four layers of the Earth, the inner core, the outer core, the mantle and the crust. The biosphere is just on the surface. This line (points to the line representing the Earth's crust) is the crust, and just above the crust is the biosphere.'

Given the limited teaching and learning time available at most schools, group work may not have been the most efficient approach to teaching this content, particularly as some learners were using previous misconceptions as a base for the learner-learner interaction.

The analysis of teachers' engagement of learners in learner-learner interactions also supports the view that, for learner-learner interaction to be beneficial (that is, for it to contribute to improvement in learners' understandings, knowledge and skills),
a) learners need meaningful content/subject matter knowledge to talk about or work with;
b) learners need a comprehensive set of skills and understandings about the processes that occur in group work.

This raises essential issues about teachers' use of group work, and about the curriculum/classroom material used in Learning Programmes.

The following excerpt from a description of the second of Teacher 10's lessons illustrates the role that learning material can play in 'blocking' the possible benefits of learner-learner interactions through group work.

The teacher made use of the 'Water cycle' Activity. Included with the material for this activity is one large but very detailed and elaborate poster of the water cycle. Teachers supplemented the material by giving each group of learners a reduced black and while photocopy of the poster. However, because the information provided on the poster/photocopy was too crowded and unfocused (both in terms of content and form) for the content needs of the learners, the essential components of the water cycle were 'lost'.

The teacher used whole class teaching to introduce the lesson on the PSP Activity, 'the water cycle'. The teacher instructed the class in English and Xhosa but mainly English. The teacher placed a large colour poster of the 'water cycle' on the board. . He provided each group of learners with one A4 sized black and white photocopy of the poster; and two PSP activity sheets with questions on them. He informed them that they were going to write the story of the water cycle.' He said he would give them 20 minutes to discuss their answers in their groups. After this the whole class would take 15 minutes to report back.

Learners worked in groups to answer the question, 'On the poster we see that different things happen to water in different places above surface of the Earth...; on the surface of the Earth...; below the surface of the Earth....'. The teacher moved from group to group providing assistance where necessary. One learner in each group acted as the scribe. After some time the teacher addressed the whole class and explained the meaning of 'above, on and below the surface' in Xhosa.

The learners worked very slowly. All the learners were eager to engage with the task but most learners struggled to answer the questions. The photocopy of the water cycle was not very clear, and many of the learners could not see the large poster on the board clearly. The tea were, 'On the surface of the Earth we get condensation; `On the surface of the Earth where the sun strikes it we get evaporation'. The teacher referred the whole class to the poster, pointing to each of the areas representing the different dimensions, 'on, above' and below'. After 20 minutes most groups had not made a great deal of progress.

The teacher called on each group leader' to present their answers to part 2, 'on the surface of Earth.' The following are examples of learners' answers, 'estuary', `surface runoff' `surface outflow; ` evaporation from dams' 'wetlands; people are cooking; 'because evaporation from the land, it goes up;- 'water tank'. The teacher selected the (edited) 'correct' answers from their responses and 'summarised' the answers they had provided by saying, `you have named seven places where we find water on the surface of the Earth - estuaries, dams, wetlands, water tanks, ...'

In contrast, the excerpt that follows illustrates how Teacher 3 was able to supplement the PSP Activity 'Travelling into Outer Space' with additional material from his own sources that provided himself and the learners with more meaningful content or subject knowledge to talk about or work with. The description also illustrates how the teacher was able to use whole class discussion

- to assist learners to work together as a class for the duration of the lesson,
- to check learners' understandings and to improve their spoken productions of their understandings.

Interestingly in this lesson the teacher used English/Xhosa but mainly Xhosa to instruct, whilst learners mainly used English in teacher-learner and learner-learner interactions.

The teacher introduced the lesson topic/activity, `Travelling to OuterSpace, and asked them what they already knew about outer space. Various learners called out, `planets; no force of gravity, satellites, stars, moons, no air.' The teacher wrote the list of their responses on the board. He asked them if they could recall the names of the nearest and furthest planets. Learners called out `Mercury' and 'Pluto'. The teacher said there was another thing they need to know and that is that 'it takes a long time to travel from Earth to the next planet'.

He asked them how they could travel from one planet to another. The learners responded `in a space ship.' He asked them for another name. A learner said, A rocket.' The teacher told them that they were going to construct a rocket that would take them to another planet. He asked them which planet they would like to go to. The class decided that they would like to travel to Jupiter

The teacher called three learners to the front of class. He provided apiece of string, a straw, and a balloon, and told one learner to blow up the balloon. He asked the class to tell him what it was that the learner was blowing into the balloon. A learner answered, 'He blow.' The teacher said 'He is blowing the air into the balloon.' When the learners were ready to demonstrate, he told the class 'to prepare for lift off' He instructed the three learners to hold the string horizontally to the ground. The class counted down from ten. The learners holding the balloon full of air released the balloon and the air propelled the balloon across the length of the string. The teacher announced that the 'lift-off had been successful.'

He asked one of the learners to tell him what had happened. A learner struggled to answer in English and was only able to say, 'The rocket...' The teacher asked someone else to help him. Another learner said, 'The air came out of the balloon... the air forces out of the balloon.' The teacher asked the class, 'What made the rocket move?' A learner said, 'the air, another learner said, 'the rocket was fighting against the force of gravity' The teacher said that it was the air that made it move and the air was fighting against the force of gravity.

The teacher got the learners to repeat the experiment but this time the learners placed the string vertically (using a drawing pin in the ceiling to hold the string in place). The teacher said, 'Let's find out if the balloon can move away from ...?'The class chorused, 'the centre of the Earth.' The experiment failed as the balloon did not move very far along the length of the string. The teacher asked the class what they think happened.

A learner said that the force of gravity had prevented the rocket from going up. The teacher said it was more difficult for the rocket to move because this time it was 'going up'. The teacher threw a pen in the air to demonstrate this. He also got a learner to stand with her arm outstretched parallel to the ground. He asked the class what was pulling the pen and the learner's arm down. The class called out 'the force of gravity.' The teacher reminded the class about the lesson they had had on the layers of the atmosphere. He checked to see if they remembered the names of the four layers. He reminded them that they had learnt that beyond the atmosphere there is 'no force of gravity'. He provided each group of learners with a photocopy of a diagram of a space ship (this was not part of the curriculum material provided with the Learning Programme).

He referred them to the diagram and pointed out that the rocket had a number of engines. He told them that the engine at the back was responsible for getting the rocket off the ground. He told them that the engine contained kerosene and oxygen and wrote both words on the board. He said that- kerosene and oxygen combined to form the gas that drove the rocket through the last layer of the Earth's atmosphere.

He asked the class what this was called. The learners called out, 'The ionosphere.' He told them that the rocket 'drops oft' the engines after it passes through the atmosphere.He said the rocket had other engine as well as a special supply of oxygen that it carried, 'like padkos.'

He referred them to the picture of a blue tank carrying oxygen in the diagram (also not part of the 'official' curriculum material). He said this was 'a reserve of oxygen' to be used as their rocket moved towards Jupiter. He told them that when the rocket left Jupiter it would 'leave' the last engine. He asked the class what they thought would make their rocket move faster. Learners called out petrol; paraffin; etc.He asked them what they could add and they said, 'more rocket fuel'.

He asked the class whether they had any other questions. A learner asked who was the first man to land on the moon. Another learner told him, 'Neil Armstrong.' Another learner said she wanted to know if there were any humans in space. The class said, 'no'. The teachers asked them, 'why?' A learner said, Because it has no life.' The teacher asked, 'What... (do you mean) space?' Another learner said, 'Because Earth is the only planet that has life on it.' The teacher said, 'We think that the Earth is the only planet that has life on it.' He asked the class why they think there is no life on other planets. A learner replied, 'no air'. The teacher said that there were other planets that had carbon dioxide. Another learner said, 'no oxygen.' The teacher said he agreed with the learner when he said that there was no oxygen.

The following extract is a description of learner-learner interaction through group work. The teacher is using the sequencing task from the Big Bang Activity in her lesson. The description illustrates how the interaction becomes meaningful because learners bring essential subject knowledge, understandings, skills and strategies to the task (in this case learners have essential knowledge of the subject matter gained from preceding activities/lessons, essential reading skills/ competencies and essential strategies for working together.)

The teacher tells the learners she is going to give them a task to complete in groups. She explains that they are going to sequence sentences but says that before they begin, they must read the text provided. There is one copy of the text per group of learners. She says they must take note of the 'facts' as they read. The small groups of 4/5 learners co-operate well and read the text together.

When they are finished, the teacher hands out one set of the sequencing task per group. She explains that they must refer to the text and use it to assist them to sequence the sentence strips provided. She says, 'What I want you to do is put this story in order so that the sentences follow *one another.'*

The teacher goes from group to group assisting' reamers wh ere they are having difficulties. She does not tell learners what to do but asks questions that refocus their thinking. After about ten minutes, she tells a member of one group to place his group's 'story' on the chalkboard and read it aloud to the rest of the class. (Each group has used Prestik to stick the strips of text onto a blank A4 sheet).The group have sequenced the text in the correct order. She calls up a member of the next group to read their text out aloud to the class and points out that their text is 'the same as the first one.' The teacher corrects learners' pronunciation as they read.

The description illustrates how group work was effective because learners had essential knowledge and understanding of the subject matter gained from preceding activities. Furthermore, essential reading skills/competencies and other skills/strategies for working together were in place. Because, learners had foundational knowledge and skills, the teacher did not have large numbers of learners who needed support, and learners were able to use the information provided in the text to formulate more scientific representations of the 'Big Bang'.

Interpretation

The analysis of criterion 5 suggests that teachers need assistance

1. in providing learners with better opportunities to use meaningful content or subject knowledge to talk about or work with in group/whole class discussions;

2. with providing all learners with opportunities to explain their thinking and understanding through whole class discussion; and

3. using whole class discussion to model and deliberately teach learners skills and strategies for working together and solving problems collaboratively. Criterion 6 - Teachers' engagement of learners in reading and using scientific text(representations

This section provides a summary, analysis and interpretation of the researchers' reports on the quality of teachers' engagement of learners in using and interpreting the texts/representations provided with the activities.

Summary

The data on teachers' engagement of learners with the concepts, processes and language to be learnt through the use of the activities provided evidence of teachers in 58.5% of the lessons using and interpreting the texts/ representations provided by giving learners opportunities to 'grapple' with text/representations independently of the teacher. In 18% of the lessons, teachers assisting them to develop the strategies they needed to interact with and interpret texts/representations independently. (See Appendix S, Teacher Ts first lesson.)

In four lessons (18%) teachers were given ratings of one, either because no texts/representations were provided or, because if they were, teachers did not use them.

In three lessons (13.5%) teachers were given ratings of two. Teachers used the texts/representations provided by telling the learners what the texts/ representations mean.

In two lessons (9%) teachers were given ratings of three. Teachers engaged learners in using the texts/representations provided in the activity by testing their comprehension of what they had read.

In nine lessons (40.5%) teachers were given ratings of four. Teachers engaged learners in using and interpreting the scientific text/representations provided in the activity by providing them with opportunities to 'grapple' with text/ representations independently of the teacher. The teachers did not assist the learners to develop the strategies they needed in order to interact with text/ representations independently of the teacher.

In four (18%) of the lessons, teachers were given ratings of five. Teachers engaged learners in using and interpreting the texts/representations provided in the activity by providing them with opportunities to 'grapple' with texts/ representations independently of the teacher. The teachers assisted the learners to develop some of the strategies they needed in order to interact with text/ representations independently of the teacher. For example, assisting them to:

- use their prior knowledge/experience and their knowledge of language;
- talk about/respond to texts/representations as they read them;
- collaborate with each other in sorting out their understanding of the texts/ representations;
- communicate their understandings of the texts/representations in their primary language and the language of learning;
- use their own words to summarise what they have read, or restate what they see as key ideas, etc.

Analysis of constraints on teachers' teaching

An analysis of data on teachers' engagement of learners in using and interpreting the texts/representations revealed that teachers need to provide learners with greater opportunities to interpret simple information such as the instructions for the activities/tasks (instead of simply telling them what the instructions mean.)

The following extract from the description of one of the teacher's lessons illustrates how some teachers did not provide learners with opportunities to practice interpreting simple information such the instructions for the activities, but simply told them what the instructions meant.

Teacher 11 is using the 'Water cycle' Activity.

> *Each group of six children has a black and white copy of the big poster on the board. The teacher has a set of questions relating to the poster. The children have a different set of questions on their desks. The teacher seems unaware that this is so. [When asked at the end of the lesson why this was so, the teacher replied that they had these questions in their files.]*
>
> *The teacher then reads out the questions, "Find 5 places on the surface of the earth where there is water?" "What happens when the sun shines on the water?"*

This suggests that teachers need additional input on how to use curriculum material effectively.

The analysis of teachers' engagement of learners in using and interpreting the texts/representations provided with the activities indicated that teachers also needed assistance in actively engaging learners in developing the strategies they need to read and interpret more complex extended text independently of the teacher.

The following extract from the description of another teacher's lesson illustrates how teachers struggled to engage learners in using and interpreting the extended texts provided with the activity because of:

- low reading levels on the part of learners who had not developed the strategies they needed to read independently; and
- the level of language used in the classroom text.

The teacher makes use of whole class teaching to introduce the lesson on Activity 3, the Big Bang. After introducing the lesson topic, she distributes the reading for the activity. There is one copy of the text per pair of learners.

The whole class reads the title of the text, 'The Big Bang theory' aloud. She tells them that a theory is an idea that has been accepted.' She says that the text explains what scientists think about how the universe started. She asks individual learners to read each paragraph, and discusses each paragraph before continuing with the next. She also provides them with a summary in Xhosa of the key content in each paragraph. For example, she tells them that they are reading about 'how galaxies are formed' saying `most scientists accept that this is how the universe began.' She tests the learners' comprehension by saying, `According to the scientists, when did the Universe start?' One of the learners answers, 'hundreds of years ago.' She tells them to look again at the text, and they all chorus, 'fifteen million years ago.'

She asks them to tell her in Xhosa what an explosion is. The learners say `ukudubula'. She explains the meaning of `explosion' by saying that, `if you put a bottle on a hot stove, the heat will cause it to explode because it is very hot.' She says that when the Big Bang occurred, `an explosion happened every particle of matter was running away from every other in all directions outwards.' She tells them that `the force of gravity forced matter outwards in all directions' and uses Xhosa to explain in more detail. She says that 'the same force of gravity made everything into clumps. Matter was pulled together by the force of gravity.' She says, 'From that explosion, the particles contributed to our being through the process of evolution, the particles kept reproducing.' She asks the class to give her examples of 'living things.' The learners call out 'animals and plants'.

When they have read the last paragraph she asks them to tell her how it is possible that 'although we are flesh and blood, we are also stardust?' One of the learners says it is `because God made people - he can take dust...' and rubs his hands to together to demonstrate how God `moulded' people. The teacher says 'that is according to the Bible'. Another learner calls out `an explosion'. The teacher tells them that it is `because we all came from (originated from) the big explosion'. She says, 'We are related to the stars, moon etc. because of the explosion that was the beginning of us all.'

The teacher organises the learners in groups. They have to work on a task that entails sequencing sentences based on the text they have just read. One set of the identical sequencing task is given to each group of learners. She explains what they need to do in order to sequence the text. She says the must start by saying `When it happened; ' Then...'.; 'Finally...' She writes this up on the board and says they must `make a story that we can read' and reminds them of stories they have heard that start with the words, `Once upon a time ...' or 'Long ago...'

The teacher tells each group to check that they have 8 `strips' of text in their envelope before they start. She reminds them that 'a story always begins with a topic/heading.' The text is written in English, but learners interact with each other in Xhosa. The teacher moves from group to group assisting groups who are having problems and telling them if their efforts are or are not going in the right direction. She reminds them to read the whole story when they are finished and to make sure that it makes sense. If it does not make sense, they must rearrange the sequence. Whilst they are busy with the task, some of the learners refer to the text they have just read.

The teacher tells the class how much time they have left to complete the task, and later reminds them again about the time constraints. When the time is up, she says that the leader of each group has to 'share' their group's sequencing with the other groups.

She asks the class what the story is about and then places a strip of text with the heading on the board. She tells them that the word 'Bang means explosion.' She calls on the 'leader' of the first group to come up and stick the first sentence on the board. The class reads out the sentence and the teacher asks all the groups to say whether they agree that it is the first sentence. The second group puts their second sentence on the board. This time other groups have different sentences from the second group. The teacher asks them to read the 'story' from the beginning and see if their sentences 'blend' or 'fits' nicely.

As the exercise progresses and the 'story' gets longer, there is increasing discrepancy between the order of each groups' strips of text. The teacher continues to ask the class to decide which 'version' is correct, and to ask the class to read the text from the beginning. However, the focus of the lesson is gradually lost as the teacher struggles to assist the different groups to correct the various versions.

interpretation

The analysis of criterion 6 suggests that:

1. teachers need to provide learners with greater opportunities to interpret simple information such as the instructions for the activities/tasks independently of the teacher;
2. teachers need more structured and direct assistance in actively engaging learners in progressively developing the strategies they need to read and interpret more complex, extended texts/scientific representations; and
3. curriculum designers and materials developers need to pay much more careful attention to the kind and levels of language used in classroom texts and activities, in particular, to how this language assists or 'blocks' second language learners from developing conceptual understanding and/or reading competency.

Criterion 7 - Teachers' engagement of learners in their assessment

The following section provides a summary, analysis and interpretation of the researcher's reports on the quality of the teachers' engagement of learners in their assessment of whether learners have learnt the concepts, processes and language that the activities are designed to teach.

Summary

The data on teachers' engagement of learners with the concepts, processes and language to be learnt through the use of the activities provided evidence of teachers in 45% of the lessons engaging learners in summative assessments, and in formative assessments through learners' incorrect answers. In 13,5% of the lessons teachers used learners' correct answers or own insights to elaborate or extend/'push' their thinking further, or to introduce more complex concepts/knowledge. (See Appendix S, Teacher 9's second lesson.)

In two lessons (9%) teachers were given ratings of one. The teachers did not engage learners in their assessment of whether learners had learnt the science concepts that the activity was designed to teach. In these lessons teachers gave no feedback, and (perhaps because they were trying to avoid negative comments) emphasised neither correct nor incorrect answers

in five lessons (22.5%) teachers were given a rating of two. Teachers engaged learners in their assessment but mismanaged the assessment. For example, by assessing the wrong concepts, or by incorrectly assessing concepts.

In five lessons (22.5%) teachers were given ratings of three for engaging learners in their assessment summatively by informing them that their responses were correct or incorrect. However, teachers did not use this information to engage them in their assessment formatively. In other words, the teachers did not use learners' mistakes to improve learning. It seemed that teachers expected learners to gain understanding through the activities with feedback from teachers at most indicating that their answers were correct or incorrect.

In seven lessons (31.5%) teachers were given a rating of four. Teachers engaged learners in their assessment summatively and used learners' incorrect answers to engage them with their assessment formatively. For example, by using learners' incorrect answers to identify and assist learners who have misconceptions or to provide them with the language that needs to be developed. However, these teachers did not use learners' correct answers to elaborate or develop/'push' their scientific conceptions and language further.

Teachers in three (13.5%) of the lessons were given a rating of five. Teachers engaged learners in their assessment of whether learners had learnt the science concepts that the activity was designed to teach summatively and formatively by using learners' incorrect and correct answers. For example, by using learners' incorrect answers to identify and assist learners who have misconceptions, and by using learners' insights and understandings to engage learners in elaborating or developing (pushing' their scientific conceptions and language further.

Analysis of constraints on teachers' teaching

An analysis of the data on teachers' engagement of learners in their assessment reveals that teachers needed assistance in ensuring that their assessment contributed to the further development of learners' understanding of science concepts/processes. In particular, the analysis reveals that teachers did not always pay careful attention to conceptual issues arising from learners' expressions of their thinking and understandings.

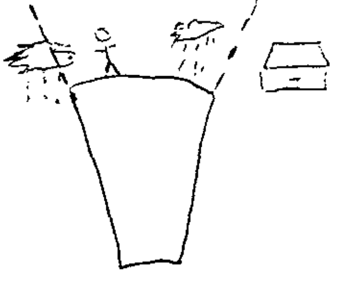
The extract that follows, from the description of the classroom interaction in one of Teachers 8's lessons, shows how the teacher did not use other learners' insights to contribute to the further development of the understandings of other learners in the class. Neither did she address conceptual issues arising from learners' incorrect responses.

The description also reveals that teachers need to help learners to pay much more careful attention to ensuring that their expressions of their thinking and understanding are clear to others and that their written expressions of their responses to questions are not too vague or general.

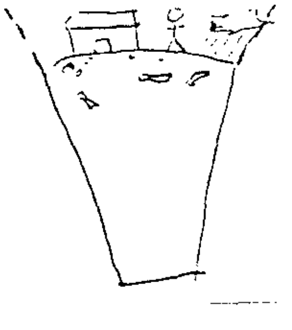
The teacher gave each learner a worksheet with a photocopy of the 'the little piece of Earth' worksheet, and explained what they had to do. Learners worked on the activity individually. All the learners participated as the teacher moved around the classroom assisting learners. Throughout the lesson she reminded them that they did not have time to waste and that they had to complete the activity in time. Learners used Xhosa with science terminology in English in teacher/learner interactions.

Some learners drew their 'piece of Earth' as if they understood the 'piece' as a piece/slice of pizza, or as if they were looking down on the surface of the Earth. For example:

Other learners drew beyond 'the boundaries' indicated on the worksheet. For example:

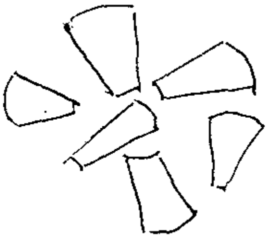


Other learners went beyond the instructions in the activity and indicated 'depth' by drawing those things which are found beneath the surface to of the Earth. For example:



The teacher encouraged those learners who had included non-living and living things (such as rocks and worms) beneath the surface and provided them with English words such as 'millipedes' and 'earthworms'. However, she did not use their insights to assist those learners who demonstrated that they did not understand. Instead she addressed their misconceptions in procedural rather than conceptual ways. For example, by saying, 'You don't have to have congested drawings'.

When they were finished, the teacher instructed all the learners to come up to the board and stick their pieces of Earth' on a large piece of cardboard. The class experienced some difficulty in fitting all the pieces together to form a circle. Some learners did not seem to grasp that the pieces had to form a circle and that they were representing something round. They placed their pieces as illustrated below:



The teacher responded by reminding them that the Earth is round.
Learners then worked individually on the activity's questions, writing the answers to the questions in English in their science books. Most of the class struggled to answer the questions, in particular to respond to the questions 'Which way up are the people?' and ' 'What do you see about the down arrows?' The teacher assisted the learners to understand the questions by re-formulating the questions, for example by saying 'What are the down arrows indicating or telling us?' An example of a learner's written response to the question 'Which way does the rain fall?' was ' I see the rain.'
Another learner wrote, ' The down arrows are telling us that other things are found below the Earth.' The teacher indicated that this was a good' answer.

The following interaction relates to the last question 'Why does everything not fall off the Earth?' and illustrates the teacher's conception of an appropriate/acceptable answer.
Learner: Because of the force of gravity.
Teacher: What do you mean by that?
Learner: It controls the gravity.
Teacher: How?
Learner: The force of gravity helps things on Earth to make it not fall.
Teacher: Right.

The analysis of teachers' engagement of learners through their assessment also indicated that teachers did not always understand the difference between encouraging learners and making them feel confident and comfortable, and actually taking responsibility for providing them with feedback on whether they were heading in the correct direction.

For example, the following excerpt from one of Teacher 1's lesson describes an occasion where a teacher did not indicate to learners that their efforts were going in the wrong direction and let them continue regardless. The teacher used the PSP activity number seven, 'The water cycle', in the lesson.

> *Towards the end of the lesson, the teacher told the class they were going to do 'a short bit of writing'. He gave them another worksheet with the heading 'On, above and below the surface'. He explained that they had to describe the 'different things that happen in different places, in other words above, on and below the surface of the Earth'. He referred them to the poster of the water cycle on the board, and to their photocopies of the poster.*
>
> *Learners discussed possible answers with their partners and then wrote down their answers in English. They really struggled to express themselves and wrote very brief and generally inappropriate answers. For example, instead of describing what they could see on the 'surface of the Earth', they wrote about evaporation/condensation etc. At the end of the lesson, the teacher collected their work.*

The analysis also indicates that it is not enough for teachers to simply collect and check their learners' written expressions of their understandings. Learners need more immediate feedback on their efforts. Teachers need to use their assessment of learners' efforts to assist learners themselves to become much more aware of:

- the importance of communicating their answers, reasoning and understanding in more competent/precise ways, and
- providing specific information and details in their oral and written responses to clearly formulated questions as opposed to vague and general information. The following extract from the description of one of Teacher 2's lessons that covered Activity 12, 'What can we do to save our ozone layer?, illustrates these needs.

> *She instructed the learners to work in groups and to answer the question, 'What we can do to save the ozone layer.' She provided each group with a large sheet of newsprint. One learner acted as the scribe for each group. The teacher provided assistance when necessary. When each group had written down three or more suggestions, she asked group leaders to tell the rest of the class what their group had suggested. As each group leader read out their suggestions, she asked them to explain or justify their answers.*
>
> *Examples of learners' responses included, 'stop smoking, stop burning shacks, dust, use ozone friendly products, stop burning shacks, use an electric stove rather than flames, chemicals from factories.' The teacher told the learners they needed to check their assumptions and find out more about the ozone layer by talking to other people and referring to books from the library. She told them they should not confuse air pollution with the ozone layer. She seemed unsure about the difference herself and said that they were to do their 'own research' for homework.*

Interpretation

The analysis of criterion 7 indicates that teachers needed greater assistance in:

1. providing learners with more immediate feedback on whether their efforts are heading in the correct direction;
2. ensuring that their assessment contributes to the further development of learners' understanding of science concepts/processes;

3. paying careful attention to connections between learners' answers and use of language, and their thinking and understanding;
4. developing learners' communicative competence and conceptual language by assisting learners to pay attention to their expressions of their answers to questions (especially their written expressions);
5. assessing whether learners have really learned what the activity intended them to learn.

6.2.2.2 Summary of the rating and ranking of teachers' engagement in terms of the criteria

Table 20 provides a summary of the researchers' ratings and ranking of teachers' engagement of learners in terms of:

- total rating allocated for all the criteria in the first lesson;
- the total rating allocated for all the criteria in the second lesson; the combined total rating for all the criteria in both lessons; and
- ranking according to the combined total rating allocated for both lessons.

TABLE 20: RATINGS AND RANKING OF TEACHERS' ENGAGEMENT OF LEARNERS

max 35 max 70

TEACHER	RATING FOR FIRST LESSON	RATING FOR SECOND LESSON	OVERALL RATING FOR BOTH LESSONS	RANKING
1	16	32	48	6
2	26	24	50	5
3	29	24	53	4
4	13	19	32	10
5	28	27	55	3
6	14	15	29	11
7	30	30	60	1,5*
8	24	18	42	9
9	26	34	60	1,5*
10	20	24	44	7,5*
11	25	19	44	7,5*

*These teachers share this ranking.

The analysis in Section 6.2.2.1 revealed that, even when teachers were using the same activities, there was much variation in the quality of different teachers engagement of learners with the Natural Sciences knowledge (content, concepts processes and language). However, the data on Table 20 reveals that, with the exception of Teacher 1, ratings for individual teachers in both of the lesson: observed did not differ significantly'[15].

15 An area for future research could be investigating the extent to which teachers' own understandings of the activity's content is related to the level of their engagement of learners In other words, an investigation into whether teachers' knowledge of the topic is related to their ability to adopt a more conceptual/process-orientated approach to dealing with the content.

The ratings and rankings of teachers' engagement of learners provided on Table 19 ensured that data on the implemented curriculum was amenable to statistical data analysis. The quantitative aspects of the analysis made it possible to explore relationships between differences and similarities in teachers' instructional practices and differences and similarities in learner attainment in the Grade 7 Natural Sciences classes (see Section 8).

6.3 Resume

The main purpose of the study of the implemented curriculum was to use the criteria and indicators on the observation schedules as a tool for gauging the level that teachers were able to use the activities to engage learners with the Natural Sciences knowledge (content, concepts, processes and language) to be learnt. The secondary purpose of the study of the implemented curriculum was to provide a description of the:

- extent of coverage of the activities in the PSP's Learning Programme; and
- the `outward forms' of the teaching strategies and approaches employed by the teachers.

Data on the extent of coverage of the PSP activities revealed variation in the coverage of the activities (some activities were not covered by all the teachers). In particular, the data revealed that:

- only one of the teachers managed to cover eleven of the activities. One teacher only managed to cover six of the activities. On average teachers covered eight of the fourteen PSP activities in the second term;
- the number of minutes of Natural Science teaching and learning in the eleven classes varied from 420 minutes to 810 minutes. On average learners received 570 minutes of Natural Science teaching and learning in the second term. By implication, during the eight weeks available for teaching in the second term learners across the eleven classes had an average of 71 minutes of Natural Sciences lessons per week.
- the number of Natural Science lessons learners in the different classes received in the second terms ranged from 13 lessons to 27 lessons. On average learners received 18 Natural Science lessons in the second term. By implication, on average learners across the eleven classes had 2.2 Natural Sciences lessons per week.

The analysis of the teachers' coverage of the activities revealed:

- discrepancies between the intended curriculum goals as expressed in the Learning Programme, and the curriculum that the teachers managed to implement during the second term of 1998.
- that disruptions in schools and teaching, and, consequently, to the 'flow' of Natural Sciences lessons, may have been major obstacles to the thorough development of the intended concepts, processes and language.

Data on the 'outward forms' of teachers' teaching strategies revealed that:

- teachers made use of group/paired work in most lessons, and made use of whole class teaching in most lessons;
- learners themselves did practical, hands-on work in most lessons, and teachers also performed demonstrations in most of the lessons;

- in most lessons learners worked on the activities in pairs/groups with assistance from the teacher;
- all or most of the learners participated actively in most of the lesson;
- teachers paced their lessons efficiently and appropriately in terms of available time in most lessons.
- learners were provided with opportunities to read, write and listen to English in most of the lessons;
- learners used Xhosa or Xhosa with science terminology in English to interact with the teacher or with other learners in most lessons.

The analysis of teachers' teaching strategies and approaches:
- revealed which strategies and approaches were most frequently employed by the teachers; and
- provided evidence of all the teachers' using PSP's language-sensitive activity-based methodology in their Natural Sciences lessons.

The analysis of data on teachers' engagement of learners with the Natural Sciences knowledge (content, concepts, processes and language) to be learnt through the use of the activities provided evidence of teachers engaging learners:

- in understanding what was required and in establishing a base for achieving the conceptual goals of the lesson, but not maintaining the focus on the conceptual goals of the lesson (for example, by continually intervening to refocus learner's attention on the conceptual goals);
- in developing some procedural understandings and process skills, but not using the activities to ask questions that required learners to ask questions for themselves;
- in using their primary language and the language of learning to express their everyday understandings of the science concepts, and in using scientific modes of communication, but not providing them with sufficient assistance in converting or re-formulating expressions of scientific conceptions/knowledge into more abstract/indirect/symbolic scientific modes of communications/ representations;
- with appropriate and correct new/additional discourse, and in focusing on meaning rather than form, but not assisting them to understand differences between their everyday language/concepts/knowledge and new science language/concepts/knowledge;
- in learner-learner interaction about the science concepts to be learnt in ways that could benefit their thinking/discourse through group work, but not using whole class discussions to assist learners to develop the skills and strategies they needed to solve problems collaboratively;
- in using and interpreting the text(s)/representations provided by giving learners opportunities to 'grapple' with text(s)/representations independently of the teacher, but not assisting them to develop the strategies they needed to interact with and interpret text(s)/representations independently;
- in summative assessments, and in formative assessments through learners' incorrect answers, but not using their correct answers or own insights to elaborate or extend/push' their thinking further.

The analysis also revealed much variation in the quality of individual teachers' engagement of learners with the Natural Sciences knowledge (content, concepts, processes and language), even when teachers were using the same activities.

An interpretation of the analysis of constraints on teachers' engagement of learners with the content, concepts, processes and language to be learnt in the Learning Programme through the use of the activities indicated that the intervention/ Learning Programme would be more effective if the Learning Programme was designed to provide learning experiences that:

- are highly focused on achieving a few strategic goals (rather than trying to provide learners with integrated learning experiences that are inclusive at the expense of achieving coherent conceptual goals);

- address concepts/processes/skills in terms of increasing cognitive complexity, or that assist learners to use concepts/processes/skills in progressively difficult ways (for example, through the use of graded reading/texts);

- the core Natural Science knowledge (content, concepts, processes, and language including Natural Science terms, definitions and vocabulary) to be learnt through the use of the activities was made much more explicit (rather than embedded) in the curriculum material.

- the curriculum designers and materials developers paid more careful attention to the kinds and levels of language used in the classroom texts and activities, in particular, to how this language assists or 'blocks' second language learners from developing conceptual understanding. In particular, paying attention to the ways in which conceptual confusion can result
  a) from the use of everyday metaphors used in an effort to 'close the gap' between learners' everyday understandings and scientific conceptions; and
  b) through differences between learners' everyday (primary) language, the language of learning (English), and the new Science language.

An interpretation of the analysis of data on teachers' use of the activities to engage learners with the knowledge to be learnt revealed that less teachers need greater assistance:

- in understanding the difference between successfully completing an activity, and using the activity to assist learners to understand particular content, concepts, processes and language;
- through curriculum material purposefully designed to 'bridge' the gap between teachers' inadequate subject matter knowledge and the needs of the intended curriculum, and to mediate the necessary subject matter for the teacher;
- through INSET directed at developing teachers' own discipline knowledge and understanding so that they are able to engage learners more spontaneously with scientific knowledge (content, concepts, processes and language) at higher levels of thinking and understanding;
- with making stronger cognitive demands on learners through questions that help learners to generate questions or hypotheses themselves. In particular, assistance in moving learners towards a higher level of understanding/ thinking through

a) the use of unusual/hypothetical situations where learners' existing conceptual frameworks are in conflict with or inadequate for solving problems or explaining the situations;
b) the inclusion of more open-ended questions cleverly formulated both to challenge learners' current thinking and to force learners to generate questions themselves or to propose alternative hypotheses or explanations that can be used to solve problems and explain unusual/ egregious phenomena or hypothetical situations;

- in providing learners with more direct support in converting/reformulating/re-interpreting expressions or realist models of scientific conceptions/knowledge into more abstract/indirect/symbolic scientific modes of communication/ representations;
- in ensuring that the learners understand the relationship between the representations/models they are working on/with and the science concepts/ knowledge they are expected to learn;
- in using differences between learners' everyday and/or scientific conceptions/ language/discourse to assist learners' to understand new concepts. In other words, assistance in using differences between learners' 'out of school' discourse and the new science discourse to help learners to understand differences between their everyday conceptions/language and the science concepts/language to be learnt;
- in establishing whether the related foundational language and understandings/conceptions taught in preceding activities/lessons are in place so that they are able to 'build' on the skills/knowledge already learnt cumulatively;
- with providing learners with appropriate, correct and clearly-defined science vocabulary, terms and definitions;
- with paying much more careful attention to how concepts are presented and developed in the language used in their teaching. In particular, paying attention to the ways in which conceptual confusion can result
  a) from the use of everyday metaphors used in an effort to 'close the gap' between learners' everyday understandings and scientific conceptions;
  b) through differences between learners' everyday (primary) language, the language of learning (English), and the new Science language;
- in providing learners with better opportunities to use meaningful content or subject knowledge to talk about or work with in group work or whole class discussions;
- with modelling and deliberately teaching learners skills and strategies for solving problems collaboratively;
- in providing learners with greater opportunities to interpret simple information such as the instructions for the activities/tasks independently of the teacher;
- in actively engaging learners in developing the strategies they need to read and interpret more complex, extended texts/scientific representations;
- in providing learners with more immediate feedback as to whether their efforts are heading in the correct direction;
- in ensuring that their assessment contributes to the further development of learners' understanding of science concepts/processes;
- with paying careful attention to connections between learners' answers and use of language, and their thinking and understanding;

- in developing learners' communicative competence and conceptual language by assisting learners to pay greater attention to their spoken and written expression of their answers to questions (especially their written expressions) so that they develop an awareness of the importance of communicating clearly for an audience;

- assessing whether learners have really learned what the activity intended them to learn.

So as to ensure that data on the implemented curriculum is amenable to statistical data analysis, teachers' engagement of learners has been rated and ranked according to the researchers' overall assessment in terms of all the criteria. This quantitative aspect of the analysis allowed for the relationship between differences and similarities in teachers' instructional practices, and learner attainment in the item tests to be explored in Section 8.

7. ASSESSING THE ATTAINED CURRICULUM

Section 6 of this report describes the implementation of the PSP's Learning Programme in the eleven Natural Sciences classrooms in terms of teachers':

- coverage of the Learning Programme;
- pedagogical strategies; and
- engagement of learners with the concepts, processes and language to be learnt.

In Section 7 the attained curriculum has been assessed in terms of evidence of growth in learner achievement (see 7.1) and attitudes (7.2) in the eleven Grade 7 classes tested.

7.1 Learner achievement

Learner achievement in the TIMSS item tests is analysed in terms of:

- improvement in learner achievement in the pre-and post-tests (including an analysis of learners' response patterns in individual items in the post-test) (see 7.1.1);
- a comparison of the sample of learners' post-test results with:
  a) the results on individual items of a control group of learners who participated in the original TIMSS:SA (7.1.2);
  b) the results of a sub-sample of the experimental learners in the PSP's performance tasks (7.1.3); and
  c) each class teacher's assessment of individual learners (7.1.4).

7.1.1 Improvement in learner achievement through a comparison of the pre- and post-test results

The pre-test scores formed the baseline for growth in learner achievement. The international averages in the TIMSS for the different content areas showed that, on average, the items in the content area 'Earth Sciences' were answered correctly by 50% of seventh graders across participating countries. The items in content area of `Environmental Issues and the Nature of Science' were answered correctly by 47% of seventh graders across the participating countries. The following table provides an indication of how the sample of Focus on Seven learners' pre-test results compared with Lower Grade (usually Grade 7) International averages for thirteen (two items consisted of two parts) of the released items in TIMSS. (International results for unreleased items could not be located).

TABLE 21: COMPARISON OF THE SAMPLES' PRE-TEST RESULTS ON INDIVIDUAL RELEASED ITEMS WITH INTERNATIONAL AVERAGES FOR THE LOWER GRADE IN TIMSS

Item		Pre- test result for Focus on Seven *	N	International Average Lower Grade
I17	Energy for Earth's water cycle	11%	407	38%
J1	Which describes Earth's surface	9%	407	36%
K17	Which position gravity act?	40%	393	49%
N5	Principal cause of acid rain	23%	403	31%
O12	Which gas greatest amount in air?	8%	409	22%
Q11	Why daylight and darkness occur	20%	389	39%
O14	Sun and moon	1%	398	51%
P3	Life on another planet	14%	382	76%
R4	Ozone layer	4%	401	43%
W1a	River – good place	19%	375	76%
W1b	River – bad place	1%	317	38%
W2	Rain from another place	10%	401	27%
Z2	Not enough water**	-	-	37%

N = Number of learners in our sample who attempted the item.

* Focus on Seven results have been 'rounded off' to whole numbers.

** Comparison of pre-test results on item and Z2 could not be made. This item required two answers. For the purposes of our study, the results for each answer were 'separated out' into two averages. The International results provided one average.

Comment:

The pre-test results for Items K17 and N5 compared reasonably favourably with the International averages at the Lower Grade. This provides evidence that some of the foundational knowledge and understanding required to answer these two test items was in place prior to the implementation of the Learning Programme. Nevertheless, overall the pre-test scores for the majority of the released items were far below the averages of the countries that participated in the TIMSS.

The fact that the pre-test scores were so low, meant that the tests were not entirely appropriate for the Focus on *Seven* study (a study which attempted to correlate learner attainment with the implemented curriculum as evidenced in classroom practice). The tests were also not entirely appropriate, in that:

- they were not specifically designed to 'match' the curriculum that the teachers intended covering over the period of the study;
- the language component of some items could have introduced difficulties for the sample of learners; and
- the reading level required for some of the items may have been too high for our sample.

However, the TIMSS items:

- were developed through a process of international consensus involving extensive input from Science educators and other experts in Science;

- had external validity in that they reflect knowledge and processes that are generally accepted to be an appropriate standard for Natural Sciences learners at the Grade 7 level; and
- represented international consensus on curricular goals in Science.

Thus, in the absence of more appropriate valid tests, we hoped that those items that closely 'matched' the intended curriculum would be effective in that they would:
- reflect change in Natural Sciences achievement over the second term; and
- provide an indication of the Natural Sciences ability of Grade 7 learners.

The TIMSS items were used to look for evidence of improvement in learner achievement through a comparison of learner achievement in each class in the pre- and post tests:
- as whole; and
- in individual items

Evidence of improvement in learner achievement in the pre- and post-tests as a whole

Tables 22 and 23 that follow provide data on pre- and post-test percentage scores for each of the eleven classes shown in decreasing order of achievement in each class.

TABLE 22 : PRE-TEST MEAN PERCENTAGE SCORE FOR THE 11 TEACHERS' CLASSES IN DECREASING ORDER[17]

Teacher	N	$\bar{X}$	SD	Min score	Max score
Teacher 3	32	26.04	15.15	0.00	52.38
Teacher 4	17	21.57	14.88	0.00	47.62
Teacher 2	47	21.18	13.28	0.00	52.38
Teacher 9	40	20.71	13.83	0.00	52.38
Teacher 8	25	17.71	7.08	0.00	28.57
Teacher 6	36	17.33	10.25	0.00	38.10
Teacher 1	31	17.20	9.01	0.00	38.10
Teacher 7	23	16.98	9.93	0.00	42.86
Teacher 11	59	14.93	8.08	0.00	42.86
Teacher 10	63	13.23	6.92	0.00	38.10
Teacher 5	43	11.07	10.01	0.00	38.10
Overall	**416**	**17.32**	**11.37**	**0.00**	**52.38**

N = Number of learners in our sample
$\bar{X}$ = Mean
SD = Standard Deviation
Min score = Minimum score obtained in each class
Max score = Maximum score obtained in each class.

17 Three types of descriptive statistics have been obtained on learner achievement in the item tests- frequencies, means or average performance, and standard deviations. The mean ($\bar{X}$), which is a measure of central tendency, provides information on the average performance of a group in the item test/s – it tells us how the group as whole performed. The standard deviation (SD) is a means of variability and is calculated as the square root of the averaged square distance of the scores from the mean. The higher the standard deviation, the more varied and more heterogeneous the group is on a given behaviour, since the behaviour is distributed more widely within the group.

TABLE 23: POST-TEST MEAN PERCENTAGE SCORES FOR THE 11 TEACHERS' CLASSES IN DECREASING ORDER

Teacher	N	$\bar{X}$	SD	Min score	Max score
Teacher 9	40	35.12	16.80	0.00	71.43
Teacher 3	32	32.14	11.60	9.52	57.14
Teacher 2	47	26.69	13.29	0.00	61.90
Teacher 4	17	23.81	13.68	9.52	57.14
Teacher 1	31	22.58	11.79	4.76	47.62
Teacher 8	25	21.90	10.91	4.76	42.86
Teacher 6	36	20.90	10.01	4.76	42.86
Teacher 7	23	20.08	8.73	9.52	57.14
Teacher 11	59	18.48	10.16	0.00	47.62
Teacher 10	63	18.22	10.94	0.00	47.62
Teacher 5	43	17.50	8.92	0.00	33.33
Overall	**416**	**23.28**	**13.01**	**0.00**	**71.43**

N = Number of learners in our sample
$\bar{X}$ = Mean
SD = Standard Deviation
Min score = Minimum score obtained in each class.
Max score = Maximum score obtained in each class.

Tables 22 and 23 reveal that:

- no class' mean score decreased in the post-test;
- the top-performing class in the pre-test as a whole was Teacher 3's class;
- the lowest-performing class in the pre-test as whole was Teacher 5 's class. (This school is a community school that draws children from poorer communities and is only partially funded by the education department)
- the top-performing class in the post-test as a whole was Teacher 9's class;
- the lowest-performing class in the post-test was Teacher 5's class;
- the average mean percentage overall for all the classes combined in the pre-test was 17.32%;
- the average mean percentage for all the classes combined in the post-test was 23.28%.

Table 24 provides data on the pre- and post-test achievement for each class and the difference in increases in mean achievement between the pre- and post-test shown in decreasing order of increases in mean achievement in each class.

TABLE 24: PRE-TEST AND POST-TEST ACHIEVEMENT OF EACH CLASS AND DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT IN DECREASING ORDER

Teacher	N	Pre-test $\bar{X}$	Post-test $\bar{X}$	% Change	t value
Teacher 9	40	20.71	35.12	14.41	5.64 ***
Teacher 2	47	21.18	29.69	8.51	4.08 ***
Teacher 5	43	11.07	17.50	6.43	3.63 **
Teacher 3	32	26.04	32.14	6.10	2.48 *
Teacher 1	31	17.20	22.58	5.38	2.84 **
Teacher 10	63	13.23	18.22	4.99	3.66 **
Teacher 8	25	17.71	21.90	4.19	2.26 *
Teacher 6	36	17.33	20.90	3.57	1.86
Teacher 11	59	14.93	18.48	3.55	2.49 *
Teacher 7	23	16.98	20.08	3.10	1.42
Teacher 4	17	21.57	23.81	2.24	.79
Overall	**416**	**17.32**	**23.28**	**5.96**	**9.76** ***

The significance of change was determined by using t-tests for paired samples[18]
N = Number of learners in our sample
$\bar{X}$ = Mean
*p<0.05 **p<0.01 ***p<0.001

Table 24 reveals that:

- no classes showed a decrease in mean achievement between the pre- and post-tests;
- the overall mean difference in improvement across all eleven classes was 5.96%;
- this overall improvement from the pre-test to the post-test for the whole sample of learners was highly significant;
- in eight of the eleven classes the improvement between the pre- and post-test was statistically significant;
- the improvement between the pre- and post-test in the two most improved classes was highly significant;
- improvement was not significant in three of the four least improved classes, possibly because of the small sample sizes;
- the class which showed the most significant improvement was Teacher 9's class. [This teacher was a top ranking teacher according to the criteria and ratings used to assess teacher's classroom practices (see Section 8)];
- the least improved classes in terms of improvement between the pre- and post-tests were those of Teacher 7 and Teacher 4. (According to the ratings

[18] The t value helps to determine how confident we can be that the differences found between two groups are not due to chance. The p value indicates the level of significance. The significance level is very important since it is related directly to whether the null hypothesis is rejected or not. When a significant difference between the two groups is found, we can reject the null hypothesis that states that there is no significant difference between groups. The conventional level of rejecting the null hypothesis is p<0.05 or p<0.01, which means that, given the size of the sample, the magnitude of the difference found between the two means would have occurred by chance fewer than five times out of 100 for p<0.05, and once out of 100 for p<0.01. In other words, the difference between means can be assumed with more than 95 (or 99) per cent confidence to be different from zero. If p<0.001 the magnitude of difference found between the two means would have occurred by chance fewer than once out of 1000.

used in the classroom observations, Teacher 4's classroom practice was ranked the second lowest. Although Teacher 7 was a top ranking teacher according to the criteria, the teacher reported that the class had 'missed' approximately 22 lessons during the second term (see Section 5);

- there was no obvious relationship between learner performance in the pre-test and increases in mean achievement between the pre- and post-test. Teachers 9, 2, and 3's classes were among the top-scorers in the pre-tests and showed significant improvement between the pre- and post-tests. However, Teacher 5's class which scored the lowest in both pre-test and the post-test made a significant improvement in the post-tests. Teacher 4's class was among the top scorers in the pre-test but showed the least improvement the post-test;

- the difference in increases in mean achievement between the most improved and the least improved class was 12.17%. The difference between the most improved class and the second most improved class was 5,90°/x. The difference between the second and the third most improved class was 2.08%. From the third most improved class to the eleventh most improved class there were negligible differences in improvement between classes clustered at the lower end of performance;

- overall the results provided evidence of growth in science achievement.

Table 25 provides data on the percentage of negative change or zero change, 1-20% change, and 21% change and more for each class and for the sample overall.

TABLE 25: PERCENTAGE CHANGES IN MEAN ACHIEVEMENT OVERALL AND FOR EACH OF THE ELEVEN CLASSES

Teacher	N	PRE-/POST TEST CHANGE		
		negative or zero change	1-20% change	21% change or more
Teacher 1	31	42	51	7
Teacher 2	47	40	34	26
Teacher 3	32	44	47	9
Teacher 4	17	47	47	6
Teacher 5	43	30	58	12
Teacher 6	36	33	64	3
Teacher 7	23	48	48	4
Teacher 8	25	44	56	0
Teacher 9	40	18	57	25
Teacher 10	63	48	46	6
Teacher 11	59	46	49	5
Overall	**416**	**40**	**50**	**10**

N = Number of learners in our sample.

Data from Table 25 reveals that overall 60% of the sample of learners' scores showed positive change in mean achievement in post-/pre-test. 10% of the results that showed a positive change showed an improvement of 21% or more. However, the Table also shows that overall 40% of the learners showed zero or negative improvement.

Evidence of improvement in learner achievement in the pre- and post-tests in individual items

An item by item analysis of improvement in learner achievement was conducted by calculating the percentage of correct responses to each item in each class. The results for the percentage of correct responses for each item in the pre- and post- tests provided a basis of comparison for improvement in learner performance on individual items in each class.

Where relevant this section includes:

- an analysis of learner response patterns in individual items in the post-tests; and
- a comparison of the overall post-test results of the sample for individual items with the international averages for each item.

Evidence of trends in learners' response across the eleven classes was calculated by calculating:
a) the percentage of correct responses to each item so as to identify the items with the highest percentage of correct answers overall in the post-tests; and
b) calculating the percentage of different types of incorrect responses to items so as to identify possible commonly held misconceptions.

In general, incorrect responses to multiple choice items were fairly evenly spread across all the distracters indicating the possibility of 'blind guessing' rather than conscious choice. However where there is evidence of some common incorrect responses, this information has been included in the analysis.

It was hoped that the TIMSS coding rubrics would enable the researchers to analyse learners' responses to the open ended questions in ways that would provide information about common misconceptions. In practice this was possible for very few items as, in general, learners' incorrect responses were so vague and general that this was not feasible. However, examples of learners' responses taken from the actual test booklets have been included in the analysis.

Thirteen of the items used in the Focus on Seven study were drawn from the TIMSS released items. To make up the necessary complement, permission to include 5 unreleased items was obtained. As these items are not available to the public, the items themselves cannot be discussed in detail, but significant data on the item test results have been included in the analysis.

Tables 26 - 37 that follow provide a comparison of the sample of learners' pre- and post- test results for the six items where the most significant improvement was evident, namely

- Item R4 - Ozone layer
- Item B1 (an unreleased item matched to Activity 1 'Inside Earth')
- Item N5 - Principal cause of acid rain
- Item W5 - Reduce air pollution (first reason) - a Population 1 item
- Item P3 - Life on another planet
- Items W1 a - River on the plain a good place

TABLE 26: PRE-TEST AND POST TEST RESULTS FOR ITEMS WHERE THE MOST SIGNIFICANT IMPROVEMENT WAS EVIDENT

Item	N	CORRECT				CHANGE†		
		Pre-test		Post-test				
		frequency	%	frequency	%	frequency	%	
R4	416	16	3.85%	135	32.45%	119	28.61	**
B1	374	214	57.22%	302	80.75%	88	23.53	**
W1a	416	81	19.47%	167	40.14%	86	20.67	**
W5	416	34	8.175	106	25.48%	72	17.31	**
P3	416	58	13.94%	97	23.32%	39	9.38	**
N5	403	92	22.83%	119	29.53%	27	6.70	*

† The significance of change was determined by using McNemar's test for related samples
*p<0.05 ***p<0.001

As the varying difficulty level of the items needs to be taken into account when reading the analysis, Table 27 provides this as background information. Items at higher scale values are the more difficult items.[19]

TABLE 27: ITEM TESTS: INTERNATIONAL DIFFICULTY INDEX

Item Number	International Difficulty Index
I17	644
J1	651
K17	571
N5	704
Q11	627
O4	485
O12	750
O14	560
P3	389
R4	583
W1a	383
W1b	632
W2	659
W5	580
Z2a	598

Item R4 - Ozone layer

This item, *Write down one reason why the ozone layer is important for all living things on earth,* is an open-response item. The scale value of the item on International Difficulty index is 583. The item together with examples of learners' responses is provided overleaf on page 119.

[19] Each item was placed onto the TIMSS International science scale based on learners' performance in both grades. The *difficulty* index is the point on the scale where learners with that level of proficiency that is scored at that level on the test as a whole, had a 65 percent probability of getting it right. For the purposes of the present study, the International Difficulty Index is a measure against which to look at the results of this study on each of the items. (The International mean for the upper grade was 516, and for the lower grade 479.)

Baucase it save the life and is the thing that kill the spray the spray killed the ozone layar

R4. Write down one reason why the ozone layer is important for all living things on Earth.

An ozone layer protects us from the Sun's rays which are called the Ultra Valolet Rays.

Atmos phere
Strato sphere
Earth SPERE

because it's portact us from UVR

Because animals can stay alive by the ozone layer and people too It help use it gives us air and evry thing

R4. Write down one reason why the ozone layer is important for all living things on Earth.

ozon layer is the foce of gravit.

Ozone is a solar system!

Becouse we can not Live without the azone layer If we Live without the azone layer the poeple can die and the animals can die and the plants can die too that is why we say we can Not Live without the azone Layer

Because it is our shield from the sun and RAIN. The sun will dry us if ozone layer we dont have in our planet EARTH

R4. Write down one reason why the ozone layer is important for all living things on Earth.

becouse is give us oxygen.

Ozone layer is proted us with chemical of violets radiation.

the sun is shaped like a boll
the earth is shaped lik a circle
the earth is shaped like an orange
the eart is shaped like an eye

Learners were given credit for references to protection against UV radiation from the sun; protection against dangerous or too strong radiation; or protection against skin cancer/sunburn. 32,6% of the sample gave correct responses in the post-test. Eight of the teachers reported that they had covered the *'Layers of the atmosphere'* activity that 'matched' the item topic. Developing learners' knowledge and understanding about the ozone layer was a key focus for this activity.

Table 28 provides a comparison of the sample of learners' pre-and post- test results for item R4.

TABLE 28: PRE- AND POST-TEST RESULTS ON ITEM R4

R4	N	Number of correct responses				CHANGE†		
		Pre-test		Post-test				
		frequency	%	frequency	%	frequency	%	
Teacher 1	31	0	0	4	12.90	4	12.90	
Teacher 2	47	0	0	14	29.79	14	29.79	**
Teacher 3	32	1	3.13	26	81.25	25	78.13	**
Teacher 4	17	0	0.00	3	17.65	3	17.65	
Teacher 5	43	2	4.65	8	18.60	6	13.95	
Teacher 6	36	3	8.33	19	52.78	16	44.44	**
Teacher 7	23	0	0.00	7	30.43	7	30.43	*
Teacher 8	25	0	0	0	0	0	0.00	
Teacher 9	40	6	15.00	34	85.00	28	70.00	**
Teacher 10	63	0	0.00	6	9.52	6	9.52	*
Teacher 11	59	0	0.00	14	23.73	14	23.73	**
Overall	**416**	**16**	**3.85**	**135**	**32.45**	**119**	**28.61**	**

† The significance of change was determined by using McNemar's test for related samples
*p<0.05 **p<0.001

Table 28 reveals that

- this item shows a highly significant improvement of 29% overall, with class mean improvements ranging from 78% to 0%.
- there was a highly significant mean improvement between the pre- and post-tests across all eleven classes combined of 23.53%;
- in 8 of the eleven classes the improvement between the pre- and post-test was statistically significant;
- improvement was not significant in two of the classes, and in one case the class scored zero in the pre- and the post-test;
- the classes which showed the most significant improvement were Teacher 3 and Teacher 9's classes (Both these teachers were top-ranking teachers according to the criteria used in the observation schedules);
- overall the results provided evidence of growth in achievement in this item.

Comment:

Data indicate that the learners had not heard of the ozone layer prior to the implementation of the Learning Programme and that the topic was dealt with (directly through Activity 7 and, possibly indirectly through other activities) by most of the teachers. The performance expectation for the item is `Understanding complex information'. Learner achievement in the item indicates that, in most classes, teachers engaged learners with the item content adequately.

However, learners' incorrect responses revealed conceptual confusion between this and other topics covered in the Learning Programme. For example, one learner wrote that 'ozone is a solar system', and another that 'ozone is the force of gravity'. These and other responses suggest that learners are operating with confused and/or fragmentary understandings of the topics covered in the Learning Programme.

Item B1 (an unreleased matched to Activity 1 `Inside Earth')

Item 131 was a multiple-choice item where learners were given the choice of one correct answer and three distracters. (A copy of the item is not included as it is unreleased.)

This item was answered correctly by 80% of those who attempted the item in the post-test. Of all the multiple choice items this item was answered by the fewest learners, namely 374 out of the total of 416 who wrote the post-test. 10,1% of the learners left this item out completely in the post-test. However, it is interesting that it is the first item in the test, and learners may have intended to return to the item later. All eleven teachers reported that they had covered the activity that 'matched' the item topic. Key concepts to be learnt through teachers' use of this activity included Earth is made up of concentric layers; gradation of heat in the layers; and how a cut away section works.

Table 145 provides a comparison of the sample of learners' pre-and post- test results for item B1.

TABLE 29: PRE- AND POST-TEST RESULTS ON ITEM B1

B1	N	Number of correct responses				CHANGE†		
		Pre-test		Post-test				
		frequency	%	frequency	%	frequency	%	
Teacher 1	31	17	54.84%	24	77.42%	7	22.58	
Teacher 2	41	22	53.66%	37	90.24%	15	36.58	***
Teacher 3	32	22	68.75%	28	87.50%	6	18.75	
Teacher 4	16	8	50.00%	14	87.59%	6	37.50	
Teacher 5	36	17	50.00%	30	88.24%	13	38.24	**
Teacher 6	32	13	40.63%	23	71.88%	10	31.25	*
Teacher 7	21	12	57.14%	17	80.95%	5	23.81	
Teacher 8	25	18	72.00%	23	92.00%	5	20.00	
Teacher 9	36	21	58.33%	33	91.67%	12	33.34	**
Teacher 10	54	30	55.56%	40	74.07%	10	18.51	
Teacher 11	52	34	65.38%	33	63.46%	1	1.92[a]	
Overall	**374**	**214**	**57.22%**	**302**	**80.75%**	**88**	**23.53**	***

† The significance of change was determined by using McNemar's test for related samples
*p<0.05 **p<0.01 ***p<0.001

Table 29 reveals that:

- there was a highly significant mean improvement between the pre- and post-tests across all the classes combined of 23.53%;
- in 5 of the eleven classes the improvement between the pre- and post-test was statistically significant;
- the improvement between the pre- and post-test in the most improved class (Teacher 2) was highly significant;
- improvement was not significant in six of the classes, and in one case there was negative improvement (In other words, fewer learners selected the correct option in the post-test than in the pre-tests);
- overall the results provided evidence of growth in achievement in this item.

Comment:

The activity that `matched' the item topic, Activity 1, was the second activity that teachers covered in the Learning Programme. The results indicate that half of the teachers successfully engaged learners with the content of this activity. This may have been because teachers were not as pressurised at the beginning of the term and may have had more time to focus on the activity content. However, the key content covered in the item was fairly explicit in the curriculum material.

Items W1 a and W1b - River on the plain bad/good place

Item W1a asks learners to apply scientific principles of water sources and physical cycles to explain why a plain containing a river might be both a good (part 1) and a bad (part 2) place for farming. The performance expectation for this item is `theorizing, analyzing, and solving problems'. The item and examples of learners' responses are provided overleaf on page 123.

For the first part of this item learners were given credit for mentioning that the soil was fertile, good or plentiful, the river would provide irrigation or water for the animals, there was plenty of space for farming, or some other reason specifically related to farming. Of the items we used this was one of the easier items and was rated the lowest on the international Difficulty Index, namely 383. (It was answered correctly by more that 70% of learners internationally). 40.6% of the sample were credited with correct responses in the post-tests. None of the teachers reported that they had covered the activity matched to this item topic.

Table 30 provides a comparison of the sample of learners' pre-and post- test results for item W1 A.

TABLE 30: PRE- AND POST-TEST RESULTS ON ITEM W1A

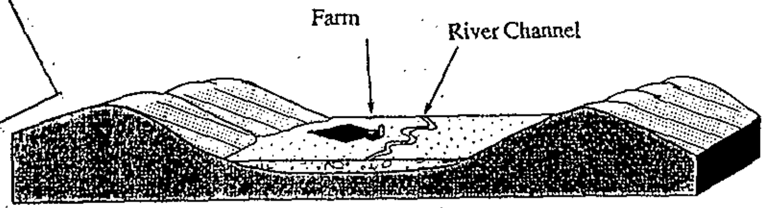
W1A	N	Number of correct responses				CHANGE†		
		Pre-test		Post-test				
		frequency	%	frequency	%	frequency	%	
Teacher 1	31	11	35.48	15	48.39	4	12.90	
Teacher 2	47	12	25.53	27	57.45	15	31.91	**
Teacher 3	32	12	37.50	15	46.88	3	9.38	
Teacher 4	17	4	23.53	7	41.18	3	17.65	
Teacher 5	43	2	4.65	22	51.16	20	46.51	**
Teacher 6	36	8	22.22	13	36.11	5	13.89	
Teacher 7	23	4	17.39	7	30.43	3	13.04	
Teacher 8	25	9	36.00	13	52.00	4	16.00	
Teacher 9	40	12	30.00	27	67.50	15	37.50	**
Teacher 10	63	3	4.76	12	19.05	9	14.29	*
Teacher 11	59	4	6.78	9	15.25	5	8.47	
Overall	**416**	**81**	**19.47**	**167**	**40.14**	**86**	**20.67**	**

† The significance of change was determined by using McNemar's test for related samples
*p<0.05 **p<0.001

However, the second part of this item, W1 b, required that learners drop their former channels of reasoning, do an about turn, and use the same information to explain why it could be a bad place for farming. This required flexible thinking more indicative of abstract reasoning or thinking. In other words, they had to move beyond a 'realist' view of the model presented in the diagram. A correct response in this case was the possibility of flooding, wind or soil erosion or some other problem directly related to farming. In the International Study the scores ranged from 15% to 70%, with 38% being the mean for the sample as a whole. The scale value on international difficulty index is 632. In our sample 4.4% of our sample were credited with correct responses in the post-test.

Table 147 provides a comparison of the sample of learners' pre-and post- test results for item W1 B.

W1. The diagram shows a river flowing through a wide plain. The plain is covered with several layers of soil and sediment.



a. Write down one reason why this plain is a good place for farming.

farmers need water for their Crops and their Animal

b. Write down one reason why this plain is NOT a good place for farming.

The river would be full oneday they will destroy their Crops

a. Write down one reason why this plain is a good place for farming.

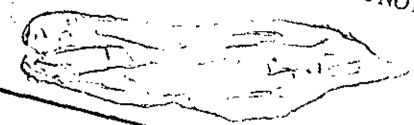
Rotation ~~on~~ on axis.

b. Write down one reason why this plain is NOT a good place for farming.

Atmosphere is the vital band of the earth around the earth.

a. Write down one reason why this plain is a good place for farm...

b. Write down one reason why this plain is NOT a good place for far...



a. Write down one reason why this plain is a good place for farming.

The place is good for because there is safiti water for farming

b. Write down one reason why this plain is NOT a good place for farming.

There are several layers of soil.

a. Write down one reason why this plain is a good place for farming.

Because it took us from here to another place.

b. Write down one reason why this plain is NOT a good place for farming.

Because sometimes ~~[illegible]~~ people donot like plain because they think the plain will crash.

W5. Write down two different things that people can do to help reduce air pollution.

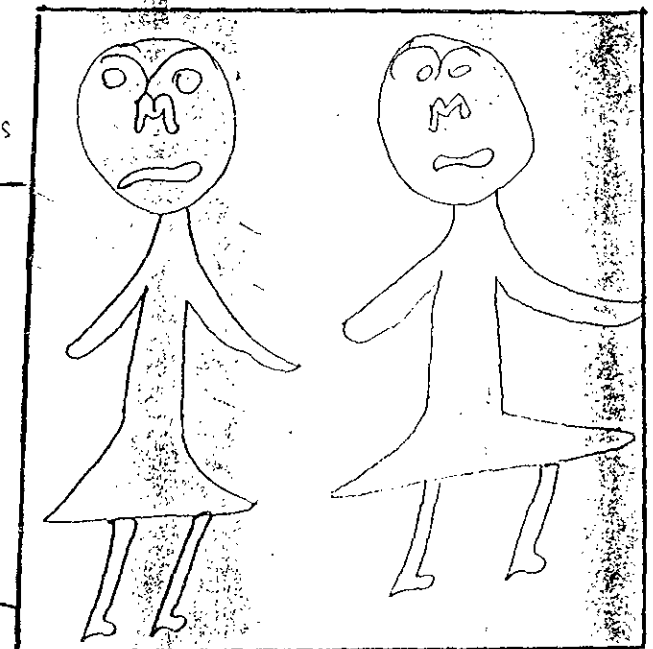
CFC
Airpollution
Arosol

W5. Write down two different things that people can do to help reduce air pollution.

The revolution and earth around the Sun.

Buy FRIDGE that have no CFCs have HCFCs

DON'T Buy SPRAY have CFCs



W5. Write down two different things that people can do to help reduce air pollution.

The people must not throw rubbish around the community They must not pollut the water

W5. Write down two different things that people can do to help reduce air pollution.

Dond thow papers in the AIR

Dont Couch in the air

W5. Write down two different things that people can do to help reduce air pollution.

1. By check the CFC chemical in the ~~fs~~ frigde

2. By not us the spray

W5. Write down two different things that people can do to help reduce air pollution.

The Air is take all ove energy.
The Air is important energy.

People can help reduce air polution by not smoking

People can help reduce air pollution by not makeing fire

People ... help reduce air pollution by not making fire

W5. Write down two different things that people can do to help reduce air pollution.

(a) Energy

(b) Matter

TABLE 31: PRE- AND POST-TEST RESULTS ON ITEM W1B

W1B	N	Number of correct responses				CHANGE†	
		Pre-test		Post-test			
		frequency	%	frequency	%	frequency	%
Teacher 1	31	0	0	2	6.45	2	6.45
Teacher 2	47	3	6.38	3	6.38	0	0.00
Teacher 3	32	1	3.13	2	6.25	1	3.13
Teacher 4	17	0	0	1	5.88	1	5.88
Teacher 5	43	0	0	1	2.33	1	2.33
Teacher 6	36	0	0	0	0	0	0
Teacher 7	23	0	0	1	4.35	1	4.35
Teacher 8	25	0	0	2	8.00	2	8.00
Teacher 9	40	0	0	3	7.50	3	7.50
Teacher 10	63	0	0	0	0	0	0
Teacher 11	59	0	0	3	5.08	3	5.08
Overall	**416**	**4**	**0.96**	**18**	**4.33**	**14**	**3.37** *

† The significance of change was determined by using McNemar's test for related samples
*p<0.01

Tables 150 and 31 reveals that

- the gain from the pre-test to the post test in both cases was significant;
- item W1 a shows a highly significant improvement of 21 % overall;
- there was a significant mean improvement between the pre- and post-tests across only four classes for item W1 a, and no significant improvement in individual classes for item W1 b.

Comment:

Given that none of the teachers reported that they had covered the activity matched to this item topic, the results for the first part of the test are interesting. It is possible that teachers covered the content or performance expectations indirectly through the use of other activities, and the results indicate that some learners were able to provide informed responses. However, the results of the second part of the test indicate that the majority of learners were unable to use their existing conceptual framework to formulate an adequate alternative hypothesis/theory/explanation to answer the second problem-solving aspect of the question. In particular, they seemed to have difficulty in answering the question because it required them to use the information provided in the diagram, and their own resources of knowledge to think more abstractly (as opposed to only using the 'concrete' information provided through the model in the diagram). Learners were also unfamiliar with the term 'plain', and in some cases assumed that the question referred to an aeroplane.

Item W5 - Reduce air pollution

Item W5 required learners to Write *down* two different things that people can do to help reduce air pollution. This item is an easier Population 1 item (developed for the Grade 3 and 4 level) that was included because the topic of the item 'matched' the intended curriculum, and because it represents foundational knowledge that learners at the Grade 7 level should have. Page 126 overleaf provides the item and examples of learners' responses.

TABLE 33: PRE- AND POST-TEST RESULTS ON ITEM W5A SECOND REASON

W5A 2nd reason	N	Number of correct responses				CHANGE†	
		Pre-test		Post-test			
		frequency	%	frequency	%	frequency	%
Teacher 1	31	3	9.68	1	3.23	-2	-6.45
Teacher 2	47	4	8.51	9	19.15	5	10.64
Teacher 3	32	8	25.00	7	21.88	-1	-3.13
Teacher 4	17	1	5.88	4	23.53	3	17.65
Teacher 5	43	1	2.33	0	0.00	-1	-2.33
Teacher 6	36	2	5.56	2	5.56	0	0.00
Teacher 7	23	0	0.00	2	8.70	2	8.70
Teacher 8	25	0	0.00	3	12.00	3	12.00
Teacher 9	40	2	5.00	3	7.50	1	2.50
Teacher 10	63	0	0.00	3	4.76	3	4.76
Teacher 11	59	3	5.08	4	6.78	1	1.69
Overall	**416**	**24**	**5.77**	**38**	**9.13**	**14**	**3.37**

† The significance of change was determined by using *McNemar's* test for related samples

Tables 151 and 33 reveal that:

- ✍ significant improvement occurred overall for the first reason;
- ✍ five teachers classes showed significant improvement for the first reason;
- ✍ there was no significant improvement overall for the second reason. Comment:

Whilst it is encouraging that significant improvement occurred overall for the first reason, the pre- and post- test results for this item suggest that, (given that this item is a Population 1 item), the sample of Grade 7 learners lacked foundational knowledge and understanding of this topic from the outset. Many learners gave responses that showed an understanding of the `generic' (more everyday) concept 'pollution' rather than knowledge of the specific (more scientific) concept 'air pollution'. Responses also revealed conceptual confusion between air pollution and the destruction of the ozone layer. These responses as well as other incorrect responses such as 'energy' and 'matter', or 'the air is important energy', indicate that learners are operating with or using fragmentary and/or confused understandings of the various topics/concepts/language covered in the Learning Programme.

Item P3 - Life on another planet

In this open response item certain information was provided about earth and a fictitious planet Athena. Learners were required to compare the two sets of information and find one reason why it would be difficult to live on Athena. In fact there were five relevant bits of information. The item and examples of learners' responses are provided overleaf on page 129.

A correct response included a reference to transportation, manufacturing changes, reduced use of fossil fuels, reducing industrial pollution and protection of trees. Efforts by individuals such as stopping smoking and stopping using aerosol cans were also marked as correct. Vague or general responses were regarded as incorrect. Two marks were allocated for this item, one for each reason. If however the second reason fell into the same category as the first, it was marked as incorrect.

Originally this item was 'matched' to Activity 14 'Our precious Earth'. None of the teachers managed to cover the item in their teaching programme. However, the topic of this item 'pollution' to some extent 'matched' to Activity Seven 'Layers of the atmosphere' which was covered by eight of the teachers. 26% of the sample gave a correct response for the first reason in the post-tests.

Table 32 provides a comparison of the sample of learners' pre-and post- test results for item W5 (first reason).

TABLE 32: PRE- AND POST-TEST RESULTS ON ITEM W5 FIRST REASON

W5A 1st reason	N	Number of correct responses				CHANGE†	
		Pre-test		Post-test			
		frequency	%	frequency	%	frequency	%
Teacher 1	31	0	0.00	9	29.03	9	29.03 **
Teacher 2	47	9	19.15	26	55.32	17	36.17 ***
Teacher 3	32	11	34.38	16	50.00	5	15.63
Teacher 4	17	3	17.65	7	41.18	4	23.53
Teacher 5	43	1	2.33	4	9.30	3	6.98
Teacher 6	36	2	5.56	4	11.11	2	5.56
Teacher 7	23	0	0.00	2	8.70	2	8.70
Teacher 8	25	0	0.00	0	0.00	0	0.00
Teacher 9	40	6	15.00	23	57.50	17	42.50 ***
Teacher 10	63	0	0.00	6	9.52	6	9.52 *
Teacher 11	59	2	3.39	9	15.25	7	11.86 *
Overall	**416**	**34**	**8.17**	**106**	**25.48**	**72**	**17.31** ***

† The significance of change was determined by using McNemar's test for related samples

*p<0.05 **p<0.01 ***p<0.001

Table 33 provides a comparison of the sample of learners' pre-and post- test results for item W5A (second reason).

23% of our sample responded correctly in the post-test. This was an easier item that was rated 389 in the International difficulty index. All teachers reported that they had covered this topic through Activity 4, 'The solar system'. A key skill to be learnt in this activity was that of 'reading a data table'.

Table 34 provides a comparison of the sample of learners' pre-and post- test results for item P3.

TABLE 34: PRE- AND POST-TEST RESULTS ON ITEM P3

P3	N	Number of correct responses				CHANGE†	
		Pre-test		Post-test			
		frequency	%	frequency	%	frequency	%
Teacher 1	31	6	19.35	7	22.58	1	3.23
Teacher 2	47	7	14.89	15	31.91	8	17.02 *
Teacher 3	32	14	43.75	19	59.38	5	15.63
Teacher 4	17	4	23.53	3	17.65	-1	-5.88
Teacher 5	43	4	9.30	4	9.30	0	0.00
Teacher 6	36	4	11.11	7	19.44	3	8.33
Teacher 7	23	4	17.39	4	17.39	0	0.00
Teacher 8	25	2	8.00	5	20.00	3	12.00
Teacher 9	40	11	27.50	19	47.50	8	20.00 *
Teacher 10	63	1	1.59	5	7.94	4	6.35
Teacher 11	59	1	1.69	9	15.25	8	13.56 **
Overall	**416**	**58**	**13.94**	**97**	**23.32**	**39**	**9.38 *** **

† The significance of change was determined by using McNemar's test for related samples
*p<0.05 **p<0.01 ***p<0.001

Table 34 reveals that:

- there was a significant improvement from pre-test to post-test;
- major gains were recorded in three teachers' dasses, Teacher 3, 2 and 9.

Comment:

The gains made in this item indicate that the activity that matched this item, 'The solar system', was fairly effective in assisting learners to develop the key concepts, skills and language linked to the item. In particular, learners' responses indicated that this activity was reasonably effective in terms of assisting learners to master the skill of reading information off a data table. However, although responses provided evidence of learners managing to extrapolate information from the table, their responses were not necessarily directed at answering the question. In other words, indications are that learners struggled to use the new skills they had learnt to solve new problems.

Furthermore, the response of a number of learners that it would be difficult for humans to live on Athena 'because it does not exist', could be interpreted as evidence that learners are unaccustomed to working/dealing with hypothetical/ theoretical situations.

Rotation on axis 1 day 200 days

Becouse athena 10% oxygen

129

P3. Bongiwe and Nomsa were discussing what it might ... live on other planets. Their science teacher gave them data about the Earth and an imaginary planet, Athena. The table shows these data.

	Earth	Athena
Atmospheric conditions	21 % oxygen	10% oxygen
	0.03% carbon dioxide	80% carbon dioxide
	78% nitrogen	5% nitrogen
	ozone layer	no ozone layer
Distance from a star like the Sun	148,640,000 km	103,600,000 km
Rotation on axis	1 day	200 days
Revolution around Sun	365 ¼ days	200 days

Write down one important reason why it would be difficult for humans to live on Athena if it existed.

Beacose there is small oxygen on Athena and no ozone layer in Athena the kilometres are small on dnd revolution around the Sun is to small wo we get small days but on Earth we get big days

for humans to live on Athena if it existed.

It would be difficult because if it existal on one pla

Write down one important reason why it would be difficult for humans to live on Athena if it existed.

Because the is less oxygen and high carb dioxide. less nitrogen. no ozone layer. oxygen which is important to human bea

They hav a big Tempreture

Write down one important reason why it would be difficult for humans to live on Athena if it existed.

~~Revolut~~ Revolution of a athena is 200days

Write down one important reason why it would be difficult for humans to live on Athena if it existed.

The important reason why it would be difficult for humes to live on Athuna it becouse Athenas oxygen was 10d° and Earth oxygen is 21d°

The Earth and Athena imaginary The Earth is bigger than the Athena is smaller than Earth the oxygen. The carbon dioxide is smalle than the Athena is 80% carbon dioxide. The Earth is 0.03% carb... di...de

Because there is no life in other planets like animals and plants.

words, fewer learners selected the correct option in the post-test than in the pre-tests.)

Comment.

Learners' response patterns provide evidence of 'blind guessing' on the part of many learners. However, the most common incorrect responses selected by learners were Options A and B. This could be because learners recognised and connected the word 'acid' to the term 'acid rain'.

Item Z2 - Not enough water

The topic of item 79 was covered by all the teachers through the use of the 'Land, water and air' Activity, and by 8 teachers through the use of 'Water cycle' Activity. However, the question is difficult (it was rated 437 for the first reason and at 598 for the second reason on the difficulty index), and the sentence construction used in the item is complex, particularly for learners whose home language is not English. The performance expectation for the item is 'theorizing, analysing, and solving problems'. In our sample, 24% of our sample got one reason correct in the post-test. Page 133 overleaf provides the item and examples of learners' responses.

Tables 36 and 37 provide a comparison of the sample of learners' pre-and post-test results for item Z2A.

TABLE 36: PRE- AND POST-TEST RESULTS ON ITEM Z2A1 (FIRST REASON)

Z2a1	N	Number of correct responses Pre-test		Number of correct responses Post-test		CHANGE†	
		frequency	%	frequency	%	frequency	%
Teacher 1	31	4	12.90	5	16.13	1	3.23
Teacher 2	47	10	21.28	23	48.94	13	27.66 **
Teacher 3	32	18	56.25	22	68.75	4	12.50
Teacher 4	17	4	23.53	4	23.53	0	0.00
Teacher 5	43	3	6.98	1	2.33	-2	-4.65
Teacher 6	36	5	13.89	5	13.89	0	0.00
Teacher 7	23	1	4.35	5	21.74	4	17.39
Teacher 8	25	6	24.00	4	16.00	-2	-8.00
Teacher 9	40	11	27.50	14	35.00	3	7.50
Teacher 10	63	4	6.35	7	11.11	3	4.76
Teacher 11	59	3	5.08	8	13.56	5	8.47
Overall	**416**	**69**	**16.59**	**98**	**23.56**	**29**	**6.97** *

† The significance of change was determined by using McNemar's test for related samples
*p<0.01 **p<0.001

Item N5 - Principal cause of acid rain

This multiple choice item (with the scale value of 704 on international difficulty index) measured learners' knowledge of the main cause of acid rain. The performance expectation for this item is 'understanding simple information'.

N5. One of the principal causes of acid rain is

N-5

A. waste acid from chemical factories being pumped into rivers

B. acid from chemical laboratories evaporating into the air

C. gases from burning coal and oil dissolving in water in the atmosphere

D. gases from air conditioners and refrigerators escaping into the atmosphere

The correct response (C) related to the burning of fossil fuels. The topic 'acid rain' was not directly covered in the Learning Programme. However, the topic 'pollution' was covered to some extent by at least 8 of the teachers. Altogether 30% of the overall sample got this item correct in the post-test. Thus the post-test result of the Item compares favourably with the international average of 31 at the lower grade.

Table 35 provides a comparison of the sample of learners' pre-and post- test results for item N5.

TABLE 35: PRE- AND POST-TEST RESULTS ON ITEM N5

N5	N	Number of correct responses: Pre-test frequency	Pre-test %	Post-test frequency	Post-test %	CHANGE† frequency	CHANGE† %
Teacher 1	30	7	23.33	8	26.67	1	3.33
Teacher 2	47	8	17.02	13	27.66	5	10.64
Teacher 3	32	9	28.13	4	12.50	-5	-15.63
Teacher 4	17	5	29.41	5	29.41	0	0.00
Teacher 5	36	4	11.11	12	33.33	8	22.22 *
Teacher 6	35	11	31.43	13	37.14	2	5.71
Teacher 7	22	4	18.18	3	13.64	-1	-4.55
Teacher 8	25	6	24.00	7	28.00	1	4.00
Teacher 9	37	15	40.54	9	24.32	-6	-16.22
Teacher 10	63	10	15.87	24	38.10	14	22.22 *
Teacher 11	59	13	22.03	21	35.59	8	13.56
Overall	**403**	**92**	**22.83**	**119**	**29.53**	**27**	**6.70 ***

† The significance of change was determined by using McNemar's test for related samples

*$p<0.05$

Table 35 reveals that:

- overall there was a significant improvement of 6.70%;
- two classes , Teachers 5 and 10's classes, showed significant improvements, while Teachers 3, 5 and 9's classes showed negative improvement (in other

TABLE 37: PRE- AND POST-TEST RESULTS ON ITEM Z2A2 (SECOND REASON)

Z2a2	N	Number of correct responses				CHANGE†	
		Pre-test		Post-test			
		frequency	%	frequency	%	frequency	%
Teacher 1	31	2	6.45	3	9.68	1	3.23
Teacher 2	47	5	10.64	7	14.89	2	4.26
Teacher 3	32	13	40.63	5	15.63	-8	-25.00 *
Teacher 4	17	2	11.76	0	0.00	-2	-11.76
Teacher 5	43	0	0.00	1	2.33	1	2.33
Teacher 6	36	2	5.56	2	5.56	0	0.00
Teacher 7	23	1	4.35	0	0.00	-1	-4.35
Teacher 8	25	1	4.00	0	0.00	-1	-4.00
Teacher 9	40	2	5.00	8	20.00	6	15.00
Teacher 10	63	5	7.94	2	3.17	-3	-4.76
Teacher 11	59	0	0	0	0	0	0.00
Overall	**416**	**33**	**7.93**	**28**	**6.73**	**-5**	**-1.20**

† The significance of change was determined by using McNemar's test for related samples
*$p<0.05$

Tables 36 and 37 reveal that

- the gain from the pre-test to the post-test for the first reason was significant;
- item Z2A9 (first reason) shows a significant improvement of 7% overall;
- Teacher 2's class shows a highly significant improvement for the first reason;
- there was negative overall mean improvement for the second reason.

Comment:

Many learners tended to give only one answer for those items that required two answers.

Learner achievement and response patterns in the post-tests in other items

Although there was no significant improvement between the pre- and post-test for the items discussed in the next section, learner achievement and responses in the post-test raised some interesting issues. Tables providing a comparison of the sample of learners' pre-and post- test results for the items have been included in Appendix T. Examples of learners' responses to extended response items (from the actual test booklets) have been included in the analysis.

Z2. Since water is a renewable resource and so much of it falls each year, theoretically there should be enough water for everyone on Earth. Write down TWO reasons why not everyone has enough water.

1. Because people waste water

2. And they don't keep water clean

Z2. Since water is a renewable resource and so much of it falls each year, theoretically there should be enough water for everyone on Earth. Write down TWO reasons why not everyone has enough water.

1= dety water

2: Corbon Morosed

Z2. Since water is a renewable resource and so much of it falls each year, theoretically there should be enough water for everyone on Earth. Write down TWO reasons why not everyone has enough water.

It is not enough rain.

It is a no taps

Becouse water important in people animal end earth

The water is grawing a ~~pha~~ plants in the land.

1. There is no enough ran for everyone.

2 People polute the water that is being stored for other people.

Z2. Since water is a renewable resource and so much of it falls each year, theoretically there should be enough water for everyone on Earth. Write down TWO reasons why not everyone has enough water.

Because is 71% on the Earth and to water is stomach all around the Earth.

Z2. Since water is a renewable resource and so much of it falls each year, theoretically there should be enough water for everyone on Earth. Write down TWO reasons why not everyone has enough water.

It's beacuse of Crime. People are stealing thats Why they have no enough water.

This item (with the scale value of 571 on international difficulty index) was answered correctly by 49% at the lower grade in the International sample. This indicates that the item is above average difficulty, and that this group on the whole achieved close to the International average. The overall result in the post-test compares favourably with the International average at the Lower Grade. All the teachers covered the Activity 6 'My little piece of Earth' where a key concept to be learnt is `Up is away from the centre, down is towards the centre, gravity pulls things to the centre.' The performance expectation for this item is 'understanding simple information'.

Comment:

Although the overall results for this item were favourable, Table T1 in Appendix T shows that three classes showed negative improvement between the pre- and post- test, and that overall the gain in learner performance was not significant. This suggests that teachers either addressed this concept inadequately in their lessons or, provided explanations that were conceptually confusing to the learners.

Item O12 - Which gas greatest amount in air

Item O12 required learners to identify the most abundant gas found in air. The options presented were A. Nitrogen, B. Oxygen, C. Carbon dioxide and D. Hydrogen. The performance expectation for this item is ' understanding simple information'.

O12. Air is made up of many gases. Which gas is found in the greatest amount? **O-12**

A. Nitrogen

B. Oxygen

C. Carbon dioxide

D. Hydrogen

In our sample, 9% got this correct in the post-test. This item was identified as the most difficult Earth Science item in the International test and was rated 750 on the International Difficulty Index. The most common misconception amongst the sample in the post-test was that oxygen was the most common gas. 65% of learners chose this option (Option B).

Although this topic was not covered directly in the any of the activities, all the teachers covered the activities (Activities 5, 6, 7, 8) where this topic could have been dealt with.

Comment:

Most of the sample chose the most 'common sense' answer, in other words, the response that most reflects an everyday understanding or knowledge of the topic. This indicates that the 'gap' between learners' everyday understandings/ knowledge and scientific conceptions/knowledge had not been addressed.

Item 117 -Energy for Earth's water cycle

Item 117, a multiple choice item, required learners to show an understanding of the Earth's water cycle and of the terms 'energy' and 'radiation'.

I-17

I17. *The source of energy for the Earth's water cycle is the*

A. wind

B. Sun's radiation

C. Earth's radiation

D. Sun's gravity

On the International Difficulty Index this item was rated 644. (This means that 65% of learners who scored 644 on the overall test, got this item correct.) The performance expectation for the item is 'understanding simple information'. Eight of the eleven teachers covered this topic through the use of Activity 11, the water cycle (Teachers 1,3,4,5,7,9, 10, and 11). Only 12,3% of the sample selected the correct option (Option 8) in the post-test.

Comment

Although this topic was covered by eight teachers, indications are that the key concepts central to the topic were not engaged with in great depth. The key concept to be learnt through the use of Activity 11 was `water cycles *between the* crust and the atmosphere'. Whilst learners appear to have gained a general understanding of this overall concept, it appears that they were not clear about the specific details of the water cycle. Learners' responses suggest that learners did not have the conceptual language to understand or respond to the question.

An additional factor that may relate to learner achievement in this item is that Activity 11 was the last topic covered by the eight teachers before the end of the term and teachers may have 'rushed' to successfully complete the activity in an attempt to complete the programme.

Item K17 -Which position does gravity act?

Item K17, a multiple choice item which tested learners' understanding of gravity was answered correctly by 44 % of the sample in the post-test.

K-17

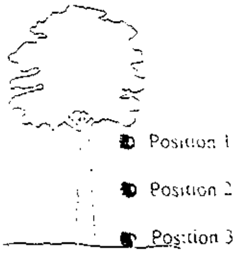
K17. The drawing shows an apple falling to the ground. In which of the three positions does gravity act on the apple?

A. 2 only

B. 1 and 2 only

C. 1 and 3 only

D. 1, 2 and 3



Comment:
Key concepts to be learnt through teachers' use of Activity four included *'planets move in fixed orbits around the sun'* and *'rotation (on own axis) and revolution (around the sun).* Test results for Item 11 (see Appendix T for details) indicate a lack of thorough engagement with the concept of rotation. In other words, teachers may have made vague reference to the concept of rotation rather than engaged learners in understanding the difference between the Earth's rotation on its own axis, and its revolution around the sun. The differences between these two terms/concepts did not appear to be clear to many learners.

Item O14 – Sun and Moon
Item O14, an open response item, was one of the most poorly answered questions in the post-test, in spite of the fact that the solar system was covered in all the classes through the use of Activity 4, *'The sun and its family'.* However, understanding this concept is difficult. Furthermore, the language structure used in the item is fairly complex, particularly for learners whose primary language is not English. The performance expectation for this item is 'theorizing, analyzing, and solving problems'. The item and examples of learners' responses to the item are included overleaf on page 139.

Comment:
Of interest here is the fact that 15% of the incorrect responses included some reference to the light. Of the incorrect responses, 17% made reference to distance in a general rather than specific sense. This could indicate that some learners experienced difficulty in explaining their thinking and understanding (particularly in English).

Some responses showed that some learners are unaccustomed to paying careful attention to ensuring that their written expressions of their thinking and understanding are clear to their 'audience'.

Item J1 -Which describe Earth's surface

Item J1, a multiple choice item was answered correctly (option B) by 12% of the learners in the post-test. Teacher 3 was the only teacher who reported covering the activity ('Continental drift) 'matched' to this item topic.

J-1

J1. Which BEST describes the surface of the Earth over billions of years?

A. A flat surface is gradually pushed up into higher and higher mountains until the Earth is covered with mountains.

B. High mountains gradually wear down until most of the Earth is at sea level.

C. High mountains gradually wear down as new mountains are continuously being formed, over and over again.

D. High mountains and flat plains stay side by side for billions of years with little change.

This item was answered correctly by 36% at the lower grade in the International test, and was rated 651on the International difficulty index, The majority of the sample of learners (61,2%) chose option D in the post-test. The performance expectation for the item is 'understanding complex information'.

Comment:

Option D presents the common sense everyday explanation rather than the scientific explanation presented in option B.

Item Q11 - Why daylight and darkness occur?
Item Q11, which required learners to choose an explanation of why daylight and darkness occur, was answered correctly by 20% of the learners in the post-test.

Q-11

Q11. Which statement explains why daylight and darkness occur on Earth?

A. The Earth rotates on its axis.

B. The Sun rotates on its axis.

C. The Earth's axis is tilted.

D. The Earth revolves around the Sun.

54% of the sample chose the option that the earth revolves around the sun (Option D). In the International sample 39% got this correct at the lower grade and 44% at the upper grade. This was rated 627 on the International Difficulty index, which makes it one of the more difficult items. The performance expectation for the item is 'understanding complex information'.

The two activities, 1 and 4, where teachers could have covered this concept, were covered by all the teachers.

Item W2 - Rain from another place

Of the TIMSS items used in the study item W2 was rated the third most difficult on the International Difficulty Index (scale value of 659), and in the International sample performance of individual countries ranged from 10 % to 60%). In the TIMSS:SA less than 10% of South African learners got this item correct (Beaton et al, 1996:3). The item and examples of learners' responses are provided overleaf on pages 141 - 142.

A fully correct response to this item, Draw a diagram to show how the water that falls as rain in one place may come from another place that is far away, required learners to use a diagram to explain the earth's water cycle. Correct responses need to depict or indicate all three steps in the water cycle, evaporation, transportation and precipitation. The extended response item required that learners apply scientific principles.

Eight of the teachers reported that they had covered the 'Water cycle' activity in their Learning Programme.

Comment:

Although most learners were not able to depict or indicate all three steps in the water cycle, 51% of the responses indicated an understanding of precipitation (rain). Learners appeared to have a 'generic' understanding of the topic, but they were not clear about the details/specifics. A key concept to be learnt through the use of the relevant activity was 'water cycles between the crust and the atmosphere'. Learners' responses to this item suggest that the information provided may have been too general for the requirements of the teachers and learners.[20]

Learners' attempts to answer this item indicate that few learners were able to convert or reformulate their expressions of their scientific understandings/ conceptions into a more abstract/ scientific model. Many responses showed little evidence of learners having moved beyond naive realist irtiages of the water cycle.

20 The results for this item raised substantive issues about the curriculum material included in the Learning Programme. For example, included with the 'Water Cycle' activity is a very detailed and elaborate poster of the water cycle. However, the essential components of the water cycle may have got 'lost' because the information provided on the poster was too crowded and unfocused both in terms of content and form for the needs of the learners and the teacher.

O14. The Sun is bigger than the Moon, but they appear to be about the same size when you look at them from the Earth. Why is this?

1 The sun is bigge than the moon because it is very hot into the sun and very big.
2 The moon is not bigge than the sun because it is not very hot.

O14. The Sun is bigger than the Moon, but they appear to be about the same size when you look at them from the Earth. Why is this?

because the sun gave us the lite

O14. The Sun is bigger than the Moon, but they appear to be about the same size when you look at them from the Earth. Why is this?

the moon mous around the sun but they appear to be a force of gravity

O14. The Sun is bigger than the Moon, but they appear to be about the same size when you look at them from the Earth. Why is this?

Because the Sun give us day and night
The moon is like start came from the bigbang

O14. The Sun is bigger than the Moon, but they appear to be about the same size when you look at them from the Earth. Why is this?

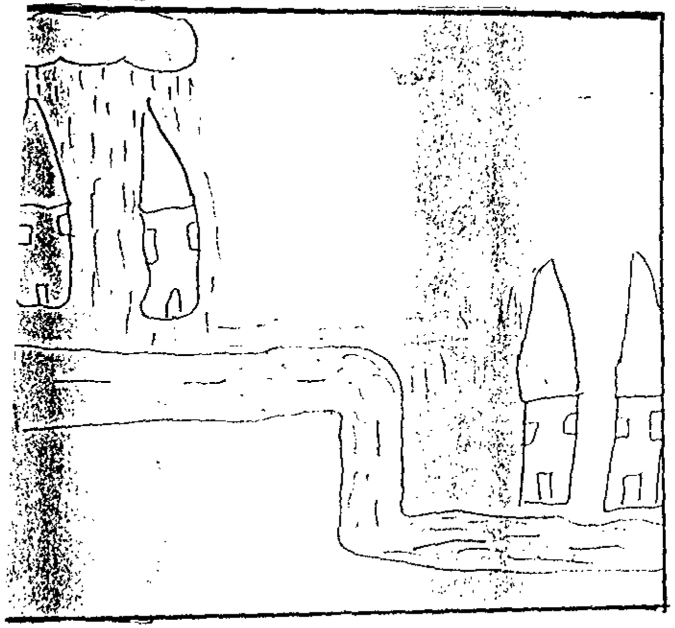
It is because the moon is closer to the sun and when we look up to see they are equally big.

O14. The Sun is bigger than the Moon, but they appear to be about the same size when you look at them from the Earth. Why is this?

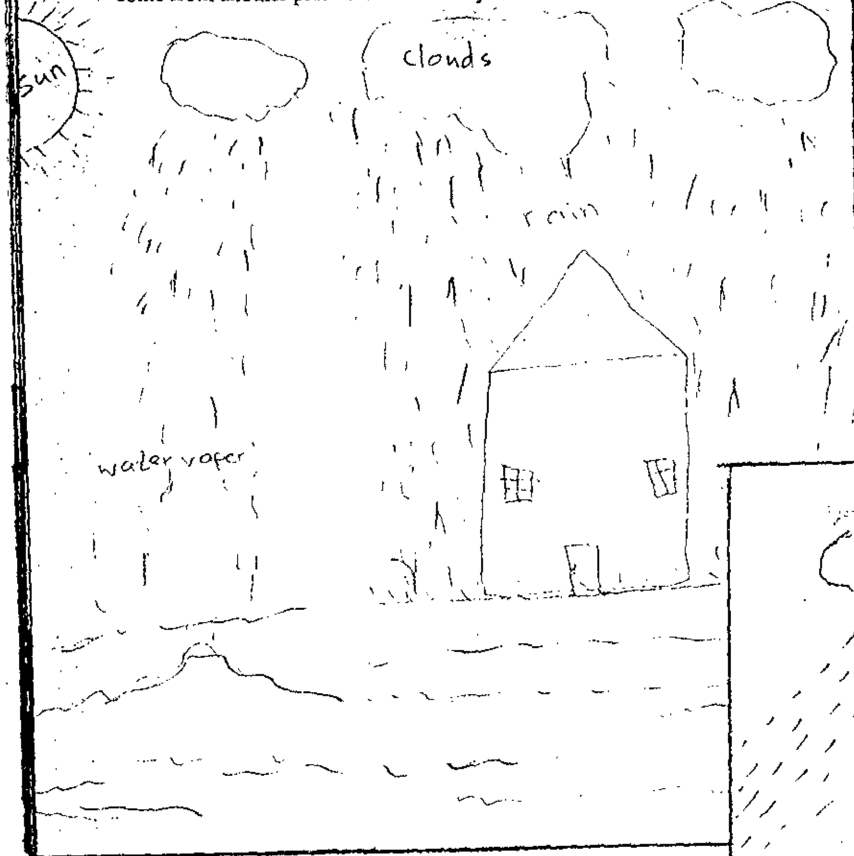
Becouse the time Earth rotates the sun is moving with the same time with moon your can thing they had the same size their are not.

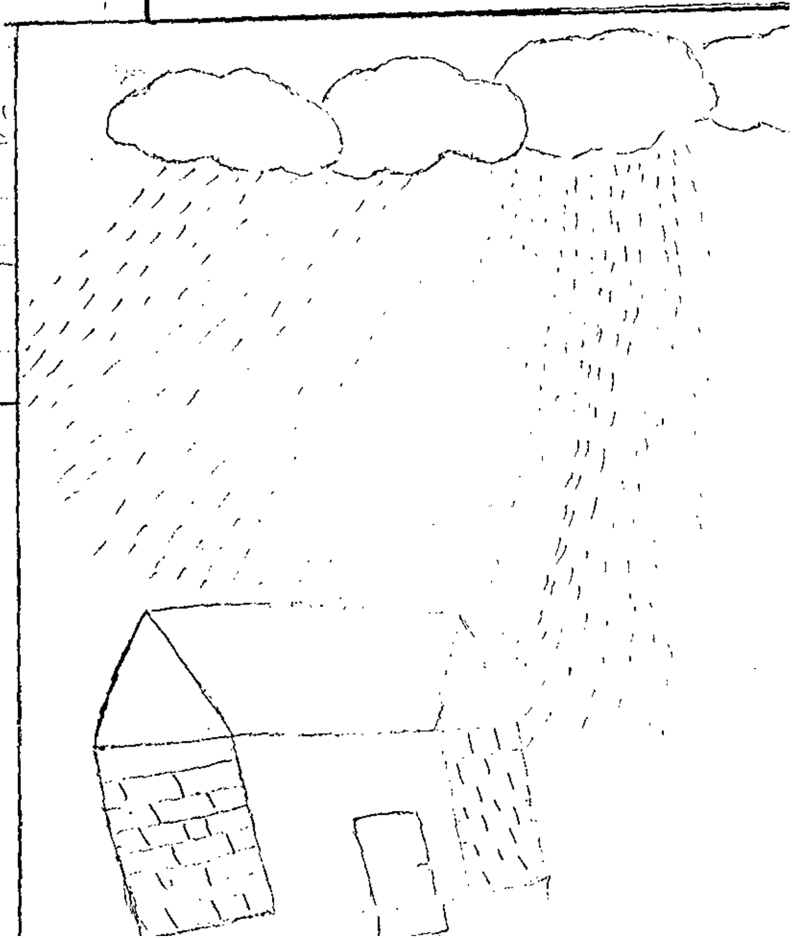
O14. The Sun is bigger than the Moon, but they appear to be about the same size when you look at them from the Earth. Why is this?

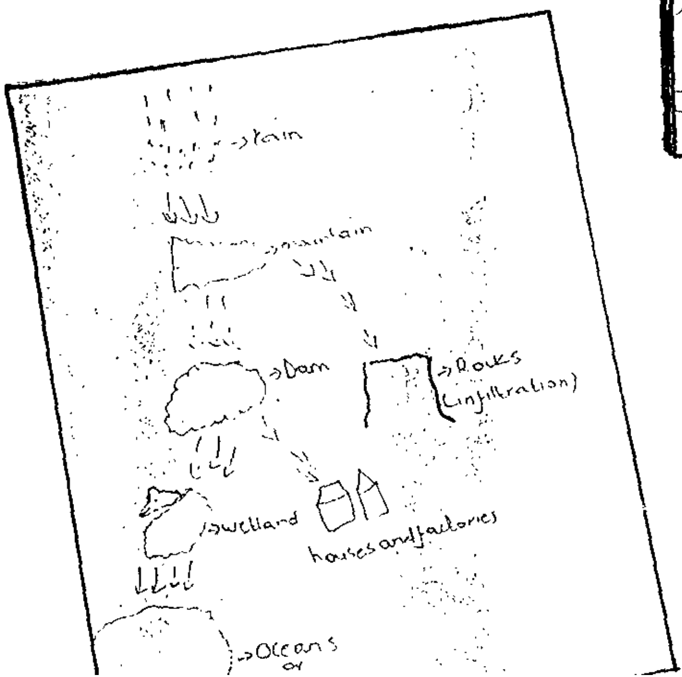
Because the moon light at Night
The Sun light at the Morning

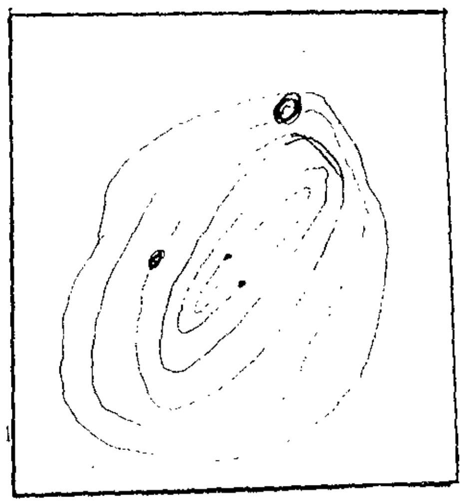


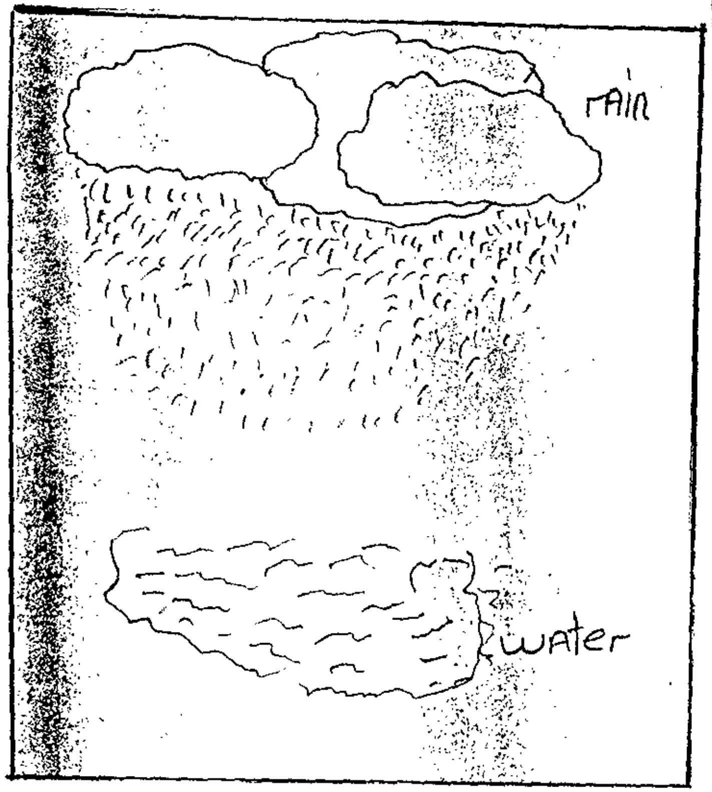
W2. Draw a diagram to show how the water that falls as rain in one place may come from another place that is far away.



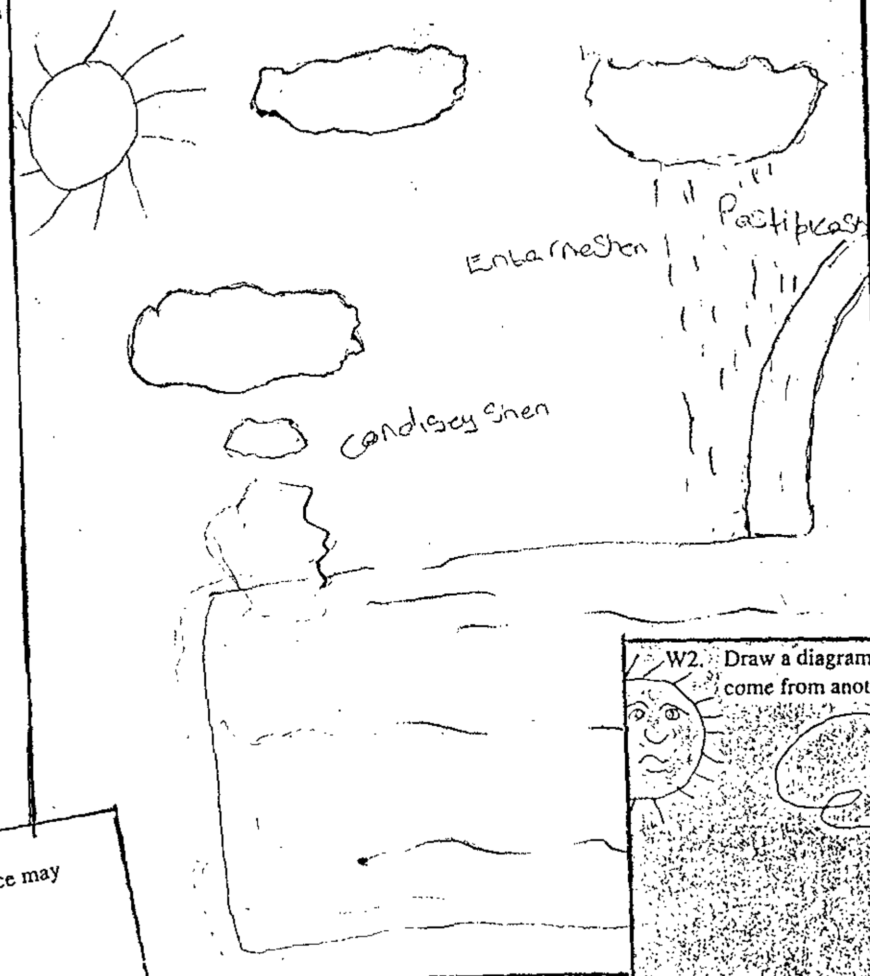




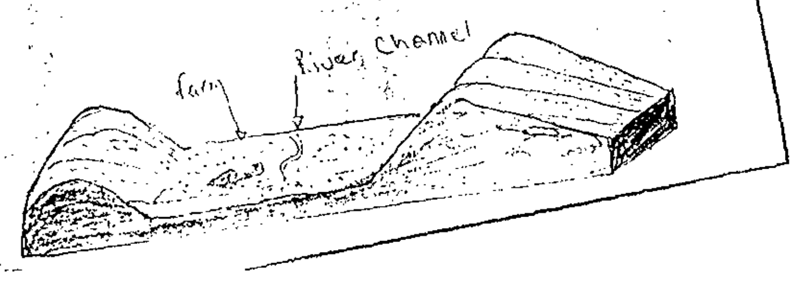




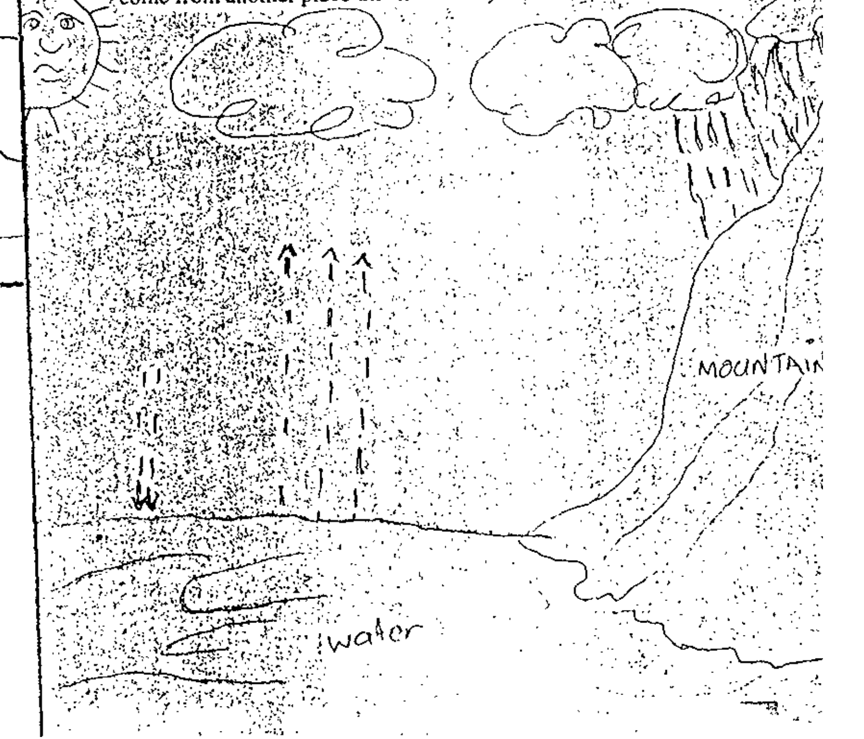
W2. Draw a diagram to show how the water that falls as rain in one place may come from another place that is far away.



W2. Draw a diagram to show how the water that falls as rain in one place may come from another place that is far away.



W2. Draw a diagram to show how the water that falls as rain in one place may come from another place that is far away.



Although the test items were of a difficulty level that precluded a sensitive analysis of what learners do know and are able to do,

a) the findings suggest that the majority of learners have an understanding of the composition of the Earth;

b) two common misconceptions revealed through learners' responses in multiple choice items, are that

  1. oxygen is the most common gas in air; and
  2. daylight and darkness occur because the earth revolves around the sun;

c) learners' responses to the extended response item on the water cycle revealed evidence that most learners had an understanding of precipitation (rain) as a `step' in the water cycle although most learners were not able to depict or indicate all three steps in the water cycle;

d) learners' responses in open-ended questions indicated that few learners were able to convert or reformulate expressions of scientific understandings/ conceptions into more formal abstract scientific models/representations. Many responses showed little evidence of learners having moved beyond naive realist notions of the concepts/topics;

e) It seems that many learners had difficulty in reading and understanding the language and information provided in the TIMSS items and that learners' efforts in the item tests were severely hampered by learners' low reading levels and inadequate second language skills (learners experienced difficulty in decoding and interpreting and answering questions in English);

f) learners' incorrect responses to a number of items reflected common sense 'everyday' understandings as opposed to scientific conceptions; revealed knowledge and understanding of general (more everyday) concepts (for example, 'pollution') rather than specific (more specialised scientific) concepts (such as 'air' pollution); and confused or fragmentary understandings of the topics/ concepts covered in the Learning Programme;

g) learners' responses to extended response items revealed that many learners

  - are unsure about how to go about answering open-ended questions;
  - had difficulty in expressing their understanding, reasoning and thinking in writing;
  - gave vague and imprecise responses lacking in specific information and detail;
  - have not learnt to pay careful attention to the whether their own written expressions of their thinking and understanding are clear to their 'audience'.

7.1.2 Comparisons between experimental and control groups

The post-test results of the experimental sample have been compared to the results of similar South African learners who participated in the larger TIMSS Study. The HSRC was able to provide frequencies on each item over twenty one urban ex- DET schools in South Africa.

However, it was impossible to identify a control group of 200 learners from intact classes to whom all of the identical items used in the Focus on Seven study were

Summary

Data from Tables 28 - 37 reveals that:

- Items where the most significant improvement is evident are items:
  R4 (ozone layer) matched to Activity 7 'Layers of the atmosphere' which was reportedly covered by eight teachers;
  B1 (unreleased item) matched to Activity 2 'Inside Earth' which was reportedly covered by all the teachers;
  W5 (population 1 item on reducing air pollution) matched to Activity7 and covered by 8 teachers;
  P3 (life on another planet) matched to Activity 4 reportedly covered by all the teachers;
  Z2 (not enough water Ist reason) matched to Activity 5 'Land, water and air' reportedly covered by all teachers, and Activity 11 'Water cycle' reportedly covered by 8 teachers;
  N5 (principal cause of acid rain) matched to Activity 14 'Precious Earth' reportedly not covered by any of the teachers;
  W1A (river on the plain/good place) matched to Activity 13 'Soil' and reportedly not covered by any of the teachers;
- Items where negative overall improvement is seen are items
  W2 (Rain from another place) matched to Activity 11 'Water cycle' reportedly covered by 8 teachers;
  Q11 (why daylight and darkness occur) matched to Activity 1 'Earth is round' and Activity 4 'Solar system' which were reportedly covered by all the teachers;
  F5 (an unreleased item) matched to Activity 'Layers of the atmosphere' reportedly covered by most teachers directly or indirectly through four of the activities;
- Achievement in the items was not always consistent with topics/subtopics that could have been covered in activities in the implemented curriculum. In other words, improvement in learner performance in those items that had/had not been directly covered in the implemented curriculum was not always lower/higher than improvement in their performance in items that had been covered. For example, the percentage gain in learner performance for item N5 (acid rain) that 'matched' Activity 'Precious Earth', which was not covered by any of the teachers, was 6,60%. The percentage gain in learner performance in item Q11 (daylight and darkness), which was covered by all of the teachers in Activities 1 and 4, showed a negative improvement of -1,54%;
- The overall post-test results for Items W5 (air pollution), N5 (acid rain), and K17 (gravity) compare favourably with the International averages for the Lower Grade. However, three classes showed negative improvement between the pre- and post- test for Item K17, and overall the gain in learner performance was not significant;
- In spite of overall gain in learner achievement, the sample of learners still lag behind their international counterparts in the countries that participated in the TIMSS.

administered (see Section 3). As a result, results for items used in the study could only be compared with the results of the twenty one urban ex-DET schools for individual items. The comparison of the post-test results of the experimental group and the control group does not provide an accurate comparison because responses coded as 'missing' or 'not reached' could not be used. Only the correct and incorrect responses could be used in the analysis as it was not possible to determine the responses of learners who did not respond.

Nevertheless, comparisons have been run between the percentage of correct and incorrect responses for the five Population 2 items where the most significant improvement was evident for the experimental group with the percentage of correct and incorrect responses of the control groups for the five items.

Table 38 compares the percentage of correct and incorrect responses for the experimental group for the five Population 2 items with the number of correct and incorrect responses of the control groups for each item.

TABLE 38: COMPARISONS OF THE PERCENTAGE OF CORRECT AND INCORRECT RESPONSES FOR THE EXPERIMENTAL GROUP WITH THE NUMBER OF CORRECT AND INCORRECT RESPONSES OF THE CONTROL GROUPS FOR EACH ITEM

Item		N	% Correct	% Incorrect	Significance†
B1 (unreleased)	EXP	374	80.7	19.3	p<0.001
	TIMSS:SA	433	63.0	37.0	
N5 *acid rain*	EXP	403	29.5	70.5	Not significant
	TIMSS:SA	105	24.8	75.2	
R4 ozone layer	EXP	416	32.5	67.5	p<0.001
	TIMSS:SA	53	3.8	96.2	
W1a good place	EXP	416	40.1	59.9	Not significant
	TIMSS:SA	176	42.6	57.4	
P3 life on another planet	EXP	416	23.3	76.7	Not significant
	TIMSS:SA	65	27.7	72.3	

† The significance of difference in correct and incorrect responses was determined by using Chi-square (X^2) tests

The Table shows that the experimental group achieved higher scores on items B1, N5 and R4. Differences were highly statistically significant for items B1 and R4. In other words, the analysis indicates that learners from the experimental group did significantly better than their counterparts in the 21 ex-DET schools in two of the five items. Interestingly, the content of both these items was a key focus for the two PSP activities that matched the tests, whilst the content of the other items was not as explicit in the curriculum material. In other words, of all the items that were 'matched' to the intended curriculum, these were the two items that most accurately matched the key content of the activities.

7.1.3 Comparison of a sub-sample of learners' post-test results with their results in the PSP's performance tasks

The PSP developed a performance assessment task linked to the curriculum goals of their Learning Programme for the second term (see Appendix L). The aim of the Task was to make it possible for the PSP to assess learners' performance in a more "hands on" activity. In particular the PSP wanted to find out how learners performed autonomously on a task without any mediation from teachers. The intention was to design a task that 'made strong demands' on learners' ability to read and interpret simple instructions and more complex extended texts independently.

The task was administered to a sub-sample of 65 learners within the eleven Grade 7 classes on 11 September (in the third term). The sub-sample consisted of eleven groups of six (in one case five) learners from each class. Each group was comprised of two learners whose post-test results were amongst:

1. The highest in the class;
2. The 'middle' of the class; and
3. The lowest in the class.

A comparison of the results of the sub-sample of learners in the performance tasks with their results in the item test has been included in the analysis of learner attainment. However, the observations and conclusions of the PSP programme developers who administered and assessed the Task have been included as they are of interest.

The Performance Task consisted of three sub-tasks. Task 9

The first task required learners to make a cut-away model of the inside of the earth'. The task was intended to measure the following proficiencies

- the model had to be spherical;
- the model had to have the correct number of concentric layers;
- the relative thickness of each layer had to be feasible;
- one quarter of the model had to be cut away to reveal the layers.

This task matched the 'Make Model' and 'Inside Earth' Activities that had been covered by all the teachers in their Learning Programmes. Key concepts to be learnt through teachers' use of this activity included that the Earth is made up of concentric layers; gradation of heat in the layers; and how a cut away section works.

The PSP found that about 15 (23%) of the 65 learners used the play dough provided for the model 'wisely and carefully', and were able to accurately recall the task and the knowledge gained from their Natural Science lessons. However, learners at the front of the hall, who could not see what other learners were doing, took much longer to start to make their models. Interestingly, the overwhelming majority of learners in the sample started with the second task.

Task 2

The second task required learners to make a drawing of their model, follow simple instructions, road complex but familiar extended text (the text was the same text that teachers had used in the activity), and use information from the text to make suitable labels for their drawing. The task was intended to measure the following proficiencies:

- the drawing had to have a suitable heading;
- the drawing had to be neat with clear lines;
- the drawing had to show a three dimensional cut away model;
- the drawing had to show the correct number of concentric layers and their relative thickness;
- the drawing had to show the (very thin) layer of air around the Earth;
- the drawing had to have the correct number of labels with the names of the layers, temperature and an indication of which layers were solid, liquid or gas.

This task closely matched the 'Inside Earth' 'Land, Water and Air' Activities covered by all the teachers in their Learning Programmes. Most learners felt comfortable with this task and started with the second rather than the first task. PSP believes that this was because learners 'remembered the task, saw an empty space that said DRAW HERE' and because 'there was a drawing on the information page to copy'. The majority of learners started with the drawing without referring to the text, this in spite of the fact that they had been verbally reminded to refer to the reading. Those learners who made reference to the text struggled to interpret and use the information.

This task is closely linked to the unreleased multiple-choice item answered correctly by 80% of the learners who attempted the item in the post-test.

Task 3

The third task required learners to follow simple instructions, read some simple but unfamiliar extended text, use information from the text to make and label a cut-away drawing of the planet Uranus, write about whether they think there is/is not life on Uranus, and justify their answer. In other words, this task required learners to apply the knowledge/understanding/skills taught in the Learning Programme to an unfamiliar situation. The task was intended to measure the following proficiencies

- the drawing had to have a suitable heading;
- the drawing had to be neat with clear lines;
- the drawing had to show a three dimensional cut away model;
- the drawing had to show the correct number of concentric layers and their relative thickness;
- learners had to write and support a hypothesis.

There was clear evidence that 5 (8%) of the 65 learners had read the extended text included with the task. Their drawings of Uranus were correct and they were able to support their hypothesis about life on Uranus. 13 (20%) of the learners' efforts showed some evidence that they had read the text.

The programme developers concluded that 'we know that we need to go much further than just developing materials with teachers. They need explicit input on strategies that would help learners access science text.'

Pearson's correlation co-efficient (r)[21] was used to measure the degree of relationship between sub-sample of learners' scores in the performance tasks and their scores in the post-test.

TABLE 39 RELATIONSHIP BETWEEN THE SUB-SAMPLE OF LEARNERS' SCORES IN THE POST-TEST AND THE SUB-SAMPLE RESULTS IN THE PSP'S PERFORMANCE TASKS

Sub-sample	r	p
N = 65	0.611	0.000*

* p<0.001

Table 39 shows a highly significant correlation between the sub-sample of learners' scores in the post-test and the sub-sample's results in the PSP's Performance Task. This indicates a very substantial measure of agreement between the assessment of the sub-sample of 65 learners through the use of the TIMSS item tests and the assessment of the sub-samples through the use of the Performance Task.

7.1.4 A comparison of the sample of learners' post-test results with each class teacher's assessment of individual learners

Data on the eleven teachers' assessment of individual learners with the learners' post-test results have been used to compare the relationship between the two sets of data. Table 40 provides data on the relationship between the sample of learners' post-test results, and each class teacher's assessment of individual learners, as well as an interpretation of the relationship.

[21] The Pearson's correlation co-efficient (r) is calculated using the actual data values. The correlation coefficient ranges from -1.00, indicating perfect negative correlation, to 1.00, indicating positive correlation. When high positive correlation is obtained between two sets of data, it means that there is a close relationship between the two sets of data. A negative correlation between the variables implies that the two sets of data are inversely related. The significance of correlation depends on the size of the correlation and the size of the sample from which it has been obtained. A zero correlation between the variables means that these two sets of data are not related to one another.

TABLE 40: RELATIONSHIP BETWEEN THE AVERAGE POST-TEST PERFORMANCE SCORE OF INDIVIDUAL LEARNERS AND TEACHERS' ASSESSMENT OF INDIVIDUAL LEARNERS IN EACH CLASS

N = 416

Teacher	r	p	Interpretation
1	0.213	0.259	Weak
2	0.664	0.000**	Moderate
3	0.559	0.001**	Moderate
4	0.070	0.790	Weak
5	0.500	0.001**	Moderate
6	0.221	0.193	Weak
7	0.422	0.045*	Moderate
8	0.227	0.274	Weak
9	0.637	0.000**	Moderate
10	0.427	0.000**	Moderate
11	0.007	0.959	Weak
Overall	0.248	0.000**	Weak

* p<0,05 ** p<0,001

Table 40 reveals that the degree of relationship between the two sets of data is statistically significant for Teachers 2, 3, 5, 7, 9, 10. This indicates a measure of agreement between the assessment of learners by these teachers and the assessment of learners through the use of the TIMSS item tests.

For the purposes of this study, the correlation between each teacher's assessment of individual learners and the results of the learners in the post-tests has been classified into three categories. r = 0.00 - 0.39 has been interpreted as a weak relationship between the two sets of data, r = 0.40 - 0.79 has been interpreted as a moderate relationship, and r = 0.80 - 1,00 has been interpreted as a strong relationship between the two sets of data,

Table 41 shows each teacher's ranking according to the researchers' overall rating for each teachers' classroom practice, and the interpretation of the relationship between the sample of learners' post-test results and each class teacher's assessment of individual learners.

TABLE 41: RELATIONSHIP BETWEEN TEACHERS' RATING FOR CLASSROOM PRACTICE AND TEACHERS' ASSESSMENT OF LEARNERS

Teacher	Teacher rank	Interpretation
1	6	Weak
2	5	Moderate
3	4	Moderate
4	10	Weak
5	3	Moderate
6	11	Weak
7	1.5	Moderate
8	9	Weak
9	1.5	Moderate
10	7.5	Moderate
11	7.5	Weak

Data on Table 41 shows that (with the exception of Teacher 10[22]), the judgement of learner performance by those teachers whom the researchers rated as more proficient (Teachers 2, 3, 5, 7 and 9) has a moderate correlation with the performance score of individual learners in the TIMSS item tests. The Table shows that the judgement of learner performance by those teachers whom the researchers rated as less proficient has a weak correlation with the performance score of individual learners in the TIMSS item tests. This weak correlation suggests that the judgments of learner performance by those teachers who were rated as less proficient are less credible. In other words, the judgment of learner performance by teachers who were rated as less proficient appears to be somewhat unreliable. On the other hand, teacher judgments by those teachers who were rated as more proficient appears to be quite reliable.

The above suggests that less proficient teachers require a more viable means of collecting assessment information than the general assessment criteria and coding rubrics provided for teachers' use in the Learning Programme. In particular, data indicates that the assessment criteria/coding rubrics developed for use by the teachers were not adequate for the needs of the less proficient teachers, and that coding rubrics for the activities needed to be much more specific.

7.2 Improvement in learners' attitudes towards Natural Sciences

Improvement in learner interest in and attitudes towards the Natural Sciences has been measured through developments in learners' interest and attitudes as reflected in the questionnaires administered at the beginning and end of the second term. Changes in learner interest in and attitudes towards the Natural Sciences has been assessed through learners' responses to the following questions:

[22] Teacher 10 was one of the more experienced teachers (he reported having had thirteen years teaching experience). This could explain why his assessment of the learner performance appears more reliable.

1. To do well in Natural Sciences at school you need

Agree/disagree

a) lots of natural talent.
b) good luck.
c) lots of hard work studying at home.
d) to memorise the textbook or notes.

2. Listed below are some of the world's environmental problems. How much do you think the application of Natural Sciences can help in addressing these problems?

Not at all/a great deal

a) air pollution.
b) water pollution.
c) damage to the ozone layer.
d) problems from nuclear power plants.

3. What do you think about Natural Sciences?

Yes/No

a) I enjoy learning Natural Sciences.
b) Natural Sciences are boring.
c) Natural Sciences are easy subjects.
d) Natural Sciences are important to everyone's life.
e) I would like a job using Natural Sciences.

Tables 42 - 44 Comparison of learners' responses in the questionnaires administered at the beginning and the end of the second term.

Table 42 provides a comparison of the sample of learners who gave 'agree' responses for Question 1 (above) in the questionnaires administered at the beginning and at the end of the second term.

TABLE 42:

Question: To do well in Natural Sciences at school you need	N	Number of 'agree' responses				CHANGE†	
		Term beginning		Term end			
		freq	%	freq	%	freq	%
Lots of natural talent	381	202	53	124	33	-78	35.29 **
Good luck	379	146	39	135	36	-11	0.72
Lots of hard work studying at home	388	321	83	337	87	16	2.50
To memorise the textbook/notes	386	320	83	299	77	-21	4.30 *

† The significance of change was determined by using McNemar's test for related samples
N = The number of learners who responded to the question in the pre- and the post questionnaire
*p<0.05 ***p<0.001

Table 176 reveals that

- a significant change in attitudes is reflected in learners' responses to two of the questions;
- a highly significant change in attitude is reflected in learners' response to the question 'To do well in Natural Sciences at school you need lots of natural talent';
- at the end of the term fewer learners reported that they believed that lots of natural talent was needed to do well in Natural Sciences, and that they needed to memorise the textbook/notes to do well in Natural Sciences.

Table 43 provides a comparison of the sample of learners who gave `a great deal' responses for Question 2 (above) in the questionnaires administered at the beginning and at the end of the second term.

TABLE 43:

Question: How much do you think the application of Natural Science can help in addressing these problems?	N	Number of 'agree' responses Term beginning		Term end		CHANGE†	
		freq.	%	freq.	%	freq.	%
Air pollution	391	312	80	351	90	39	9.68 *
Water pollution	391	327	84	354	91	25	10.09 *
Damage to the ozone layer	390	314	80	331	85	17	2.53
Problems with nuclear power plants	390	314	80	331	85	17	2.48

† The significance of change was determined by using McNemar's test for related samples
N = The number of learners who responded to the question in the pre- and the post questionnaire
*$p<0.01$

Table 43 reveals that:

- a significant change in attitudes is reflected in learners' responses to two of the questions about the application of Natural Sciences in addressing the problems of air pollution and water pollution;
- at the end of the term more learners reported that they thought that the application of Natural Sciences can help 'a great deal' in addressing the problems of air pollution and water pollution.

Table 44 shows a comparison of the sample of learners who gave 'yes' responses for Question 3 (above) in the questionnaires administered at the beginning and at the end of the second term.

TABLE 44:

Question: What do you think about Natural Sciences?	N	Number of 'YES' responses				CHANGE†	
		Term beginning		Term end			
		freq.	%	freq.	%	freq.	%
I enjoy learning Natural Sciences	388	343	88	338	87	-5	0.23
Natural Sciences are boring	386	94	24	74	19	-20	3.11
Natural Sciences are easy subjects	390	219	56	183	47	-36	8.75 *
Natural Sciences are important to everyone	384	360	94	335	87	-25	8.35 *
I would like a job using Natural Sciences	386	334	86	317	82	-17	3.41

† The significance of change was determined by using McNemar's test for related samples
N = The number of learners who responded to the question in the pre- and the post questionnaire
* $p<0.01$

Table 177 reveals that:

- a significant change in attitudes is reflected in learners' responses to the two questions about whether Natural Sciences are easy subjects, and whether Natural Sciences are important to everyone's life;
- at the end of the term fewer learners reported that they thought that Natural Sciences are easy subjects, and that Natural Sciences are important to everyone's life.

Data on changes in learner interest in and attitudes towards the Natural Sciences reveals that a significant change in attitude is reflected in learners' response to the questions:

- 'To do well in Natural Sciences at school you need lots of natural talent' and `To do well in Natural Science at school you need to memorise the textbook/notes';
- about the application of Natural Sciences in addressing the problems of air pollution and water pollution;
- about whether Natural Sciences are easy subjects, and that Natural Sciences are important to everyone's life

At the end of the term:

- significantly fewer learners reported that they believed that lots of natural talent was needed to do well in Natural Sciences, and that they needed to memorise the textbook/notes to do well in Natural Sciences.
- significantly more learners reported that they thought that the application of Natural Sciences can help `a great deal' (as opposed to 'not at all) in addressing the problems of air pollution and water pollution.
- however, significantly fewer learners reported that they thought that Natural Sciences are easy, and that Natural Sciences are important to everyone's life.

7.3 Resume

The study of the attained curriculum revealed that:

- no classes showed a decrease in mean achievement between the pre- and post-tests;
- the overall mean difference in improvement across all eleven classes was 5.96%;
- this overall improvement from the pre-test to the post-test for the whole sample of learners was highly significant;
- in eight of the eleven classes the improvement between the pre- and post-test was statistically significant;
- the improvement between the pre- and post-test in the two most improved classes was highly significant;
- improvement was not significant in three of the four least improved classes;
- the class which showed the most significant improvement was Teacher 9's class. (This teacher was a top ranking teacher according to the criteria and ratings used to assess teacher's classroom practices(see Section 8)];
- the least improved classes in terms of improvement between the pre- and post-tests were those of Teacher 7 and Teacher 4. (According to the ratings used in the classroom observations, Teacher 4's classroom practice was ranked the second lowest. Although Teacher 7 was a top ranking teacher according to the criteria, the teacher reported that the class had 'missed' approximately 22 lessons during the second term (see Section 5);
- there was no obvious relationship between learner performance in the pre-test and increases in mean achievement between the pre- and post-test. Teachers 9, 2, and 3's classes were among the top-scorers in the pre-tests and showed significant improvement between the pre- and post-tests. However, Teacher 5's class which scored the lowest in both pre-test and the post-test made a significant improvement in the post-tests. Teacher 4's class was among the top scorers in the pre-test but showed the least improvement the post-test;
- the difference in change between the most improved and the least improved class was 12.17%. The difference between the most improved class and the second most improved class was 5.90%. The difference between the second and the third most improved class was 2.08%. From the third most improved class to the eleventh most improved class there were negligible differences in improvement between classes clustered at the lower end of performance;
- overall the results provided evidence of growth in science achievement;
- overall 60% of the sample of learners' scores showed positive change in mean achievement in post-/pre-test;
- 10% of the results showed a positive change showed an improvement of 21 or more;
- Items where the most significant improvement is evident are items:
  R4 (ozone layer) matched to Activity 7 'Layers of the atmosphere' which was reportedly covered by eight teachers;
  B1 (unreleased item) matched to Activity 2 'Inside Earth' reportedly which was reportedly covered by all the teachers;

W5 (population 1 item on reducing air pollution) matched to Activity7 and covered by 8 teachers;
P3 (life on another planet) matched to Activity 4 reportedly covered by all the teachers;
Z2 (not enough water Ist reason) matched to Activity 5 'Land, water and air' reportedly covered by all teachers, and Activity 11 'Water cycle' reportedly covered by 8 teachers;
N5 (principal cause of acid rain) matched to Activity 14 'Precious Earth' reportedly not covered by any of the teachers;
W1A (river on the plain/good place) matched to Activity 13 'Soil' and reportedly not covered by any of the teachers;

- Items where negative overall improvement is seen are items
W2 (Rain from another place) matched to Activity 11 'Water cycle' reportedly covered by 8 teachers;
Q11 (why daylight and darkness occur) matched to Activity 1 'Earth is round' and Activity 4 `Solar system' which were reportedly covered by all the teachers;
F5 (an unreleased item) matched to Activity 'Layers of the atmosphere' reportedly covered by most teachers directly or indirectly through four of the activities;
- Achievement in the items was not always consistent with topics/subtopics that could have been covered in activities in the implemented curriculum. In other words, improvement in learner performance in those items that had/had not been directly covered in the implemented curriculum was not always lower/higher than improvement in their performance in items that had been covered. For example, the percentage gain in learner performance for item N5 (acid rain) that 'matched' Activity 'Precious Earth', which was not covered by any of the teachers, was 6,60%. The percentage gain in learner performance in item 011 (daylight and darkness), which was covered by all of the teachers in Activities 1 and 4, showed a negative improvement of -1,54%;
- The overall post-test results for Items W5 (air pollution), N5 (acid rain), and K 17 (gravity) compare favourably with the International averages for the Lower Grade. However, three classes showed negative improvement between the pre- and post- test for Item K17, and overall the gain in learner performance was not significant.

In spite of overall gain in learner achievement:

- 40% of the learners showed zero or negative improvement;
- the sample of learners still lag behind their international counterparts in the countries that participated in the TIMSS.

Although the test items were of a difficulty level that precluded a sensitive analysis of what learners do know and are able to do:

- the findings suggest that the majority of learners have an understanding of the composition of the Earth;
- two common misconceptions revealed through learners' responses in multiple choice items, are that:
  1. oxygen is the most common gas in air; and
  2. daylight and darkness occur because the earth revolves around the sun;

- although most learners were not able to depict or indicate all three steps in the water cycle, learners' responses to the extended response questions on the `water cycle' provided evidence of an understanding of precipitation (rain) as a `step' in the water cycle;
- learners' responses in open-ended questions indicated that few learners were able to convert or reformulate their expressions of their scientific understandings/conceptions into more formal abstract scientific models. Many responses showed little evidence of learners having moved beyond naive realist notions of the concepts/topics;
- it seems that many learners had difficulty in reading and understanding the language and information provided in the TIMSS items and that learners' efforts in the item tests were severely hampered by learners low reading levels (learners experienced difficulty in decoding and interpreting instructions or questions);
- learners' incorrect responses to a number of items reflected common sense 'everyday' understandings as opposed to scientific conceptions; or revealed knowledge and understanding of general concepts (for example, `pollution') rather than specific concepts (such as `air' pollution); or indicated that learners were operating with confused or fragmented understandings of the topics /concepts covered in the Learning Programme;
- learners' responses to extended response items revealed that many learners:
  a) are unsure about how to go about answering open- ended questions;
  b) had difficulty in expressing their reasoning and thinking in writing;
  c) gave vague and imprecise responses lacking in specific information and detail;
  d) have not learnt to pay careful attention to whether their own written expressions of their thinking and understanding are clear to their 'audiences'.

A comparison of the percentage of correct and incorrect responses for the five Population 2 items where the most significant improvement was evident for the experimental group with the percentage of correct and incorrect responses of the control groups for the five items, indicated that the experimental group achieved higher scores on items B1, N5 and R4. However, differences were statistically significant only for items B1 and R4. In other words, the analysis indicated that learners from the experimental group did significantly better than their counterparts in the 21 ex-DET schools in two of the five items. Interestingly the content of both these items was a key focus for the two PSP activities that matched the tests, whilst the content of the other items was not as explicit in the curriculum material. In other words, of all the items that were `matched' to the intended curriculum, these were the two items that most accurately matched the key content of the activities.

The PSP used a Performance Task to assess:

- learners' performance in a more "hands on" activity;
- how learners performed autonomously on a task without any mediation from teachers;
- learners' ability to read and interpret simple instructions and more complex extended texts independently.

The task was administered to a sub-sample of 65 learners within the eleven Grade 7 classes on 11 September (in the third term). The sub-sample consisted of eleven groups of six (in one case five) learners from each class. Each group was comprised of two learners whose post-test results were amongst:

1. The highest in the class;
2. The `middle' of the class; and
3. The lowest in the class.

The observations of the PSP programme developers showed that most learners (at least two thirds) struggled:

- to read and understand simple instructions and to use and interpret more complex information or extended texts independently;
- to make and interpret a formal scientific model or representation;
- to interpret, organise and use scientific data;
- to support their hypotheses and communicate effectively.

A comparison of the results of the sub-sample of learners in the performance tasks with their results in the item test revealed a highly significant correlation between the sub-sample of learners' scores in the post-test and the sub-sample's results in the PSP's Performance Task. This indicates a very substantial measure of agreement between the assessment of the sub-sample of 65 learners through the use of the TIMSS item tests and the assessment of the sub-samples through the use of the Performance Task.

Data on each teacher's ranking according to the researchers' rating for each teacher's classroom practice, has been compared with an interpretation of the relationship between the sample of learners' post-test results and each class teacher's assessment of individual learners. The comparison suggests that the teachers who were rated as more proficient were able to rate their learners' performance quite reliably (whereas the ratings of the teachers who were rated as less proficient were quite unreliable). This suggests that the assessment criteria/coding rubrics developed for use by the teachers way be adequate for the needs of more proficient teachers, but that coding rubrics for less proficient teachers need to be much more specific.

A significant change in learner attitudes at the end of the term was reflected in learners' response to the questions about:

- whether you need lots of natural talent, or to memorise the textbook/notes in order to do well in Natural Sciences;
- the application of Natural Sciences in addressing the problems of air pollution and water pollution;
- whether Natural Sciences are easy subjects, and that Natural Sciences are important to everyone's life.

At the end of the term

- significantly fewer learners reported that they believed that lots of natural talent was needed to do well in Natural Sciences, or that they needed to memorise the textbook/notes to do well in Natural Sciences;
- significantly more learners reported that they thought that the application of Natural Sciences can help 'a great deal' (as opposed to 'not at all) in addressing the problems of air pollution and water pollution; and
- significantly fewer learners reported that they thought that Natural Sciences are easy subjects.

However, significantly fewer learners reported that Natural Sciences are important to everyone's life.

8. STUDYING THE RELATIONSHIP BETWEEN THE ATTAINED CURRICULUM, THE IMPLEMENTED CURRICULUM, AND SOCIAL AND EDUCATIONAL CONTEXTS FOR LEARNING AND TEACHING

Selected items from the TIMSS tests were used to measure the attained curriculum in Section 7 because they:

a) captured the topics/subtopics that the teachers intended covering in their Grade 7 Natural Sciences lessons in the second term;
b) assessed formal classroom Natural Sciences that the sample of learners were unlikely to acquire in everyday contexts, but that needed to be mediated by the teachers; and
c) represent International consensus on learner performance in standardised tests at the Grade 7 level.

Data presented in Section 7 provided evidence of a statistically significant improvement between the pre- and post-test in overall learner achievement, and in eight of the eleven classes. However, the TIMSS model takes into account the interconnected nature of the different aspects of the education system. Thus the conceptual framework includes a number of integrated contextual factors that could have contributed to differences in learner achievement.

Section 8 of this report provides an analysis of the relationship between the attained curriculum (improvement in learner achievement in the item tests) and key variables in:

- the social and educational contexts for learning and teaching (see 8.1); and
- the implemented curriculum (see 8.2).

In particular, the section focuses on relationships between differences in increases in mean achievement between pre- and post-test scores for the experimental group and key school, teacher, classroom and learner variables, and variables in learners' 'opportunity to learn.'

Section 8.1 focuses on relationships between differences between pre- and posttest results with key school, teacher, classroom, learner variables.

Section 8.2 focuses on relationships between the differences between learners' pre- and post test results and variables in:

a) the number of minutes of Natural Sciences lessons learners had in the second term;

b) each teacher's coverage of PSP Learning Programme through the use of the activities; and

c) each teacher's overall score/ranking in terms of the criteria used to describe teachers' engagement of learners in the two lessons observed.

Obviously, the results that emerged from the study of the relationship between the attained curriculum, the social and education context for learning, and the implemented curriculum need to be treated with caution because of the small sample of schools and teachers used in the study. For this reason, nonparametric tests were used (Mann-Whitney, Kruskal-Walls). However, the findings do suggest trends for further investigation through a larger study using bigger samples of schools, teachers and learners.

8.1 Relationship between attained curriculum the social and educational context for learning

Data on the social and educational contexts for learning indicated that the sample of schools, teachers and learners formed relatively homogenous groups. However, data also revealed key school and classroom variables, and variables in teacher backgrounds that could have contributed to differences in learner achievement. For example, variables in school characteristics such as the size of the school; teacher characteristics such as teachers' experience, or qualifications, or attendance at the PSP workshops; and variables in classroom characteristics such as the class size, the average age of learners in a class, etc.

The tables that follow provide data on differences in increases in mean achievement between pre- and post-test scores according to the following key variables:

- school enrolment (size);
- teacher age;
- teacher qualifications;
- by year of teacher's last formal academic qualification;
- teacher experience;
- Natural Sciences specialist teacher;
- teachers' attendance at PSP workshops;
- teacher feeling prepared/confident teacher; teaching as teacher's first choice of career;
- teacher would change career is he/she had a choice;
- number of books the teacher has at home;
- class size;
- average age of learners in class;
- number of Natural Science lessons missed;
- gender;
- number of learners aged 13 or younger and number of learners at age 14 and older;
- number of books at learner's home;
- parents' educational levels;
- learner perception of their own success in Natural Sciences; and
- learner attitude towards Natural Sciences.

8.1.1 Difference in increases in mean achievement by key school and teacher variables

Differences in increases in mean achievement with school enrolment

Variables in the schools' enrolment were re-coded and classified into two categories, schools with less than 1000 learners, and schools with more than 1000 learners. Table 45 shows the differences in increases in mean achievement between pre- and post-test scores according to school enrolment/ size.

TABLE 45: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO SCHOOL ENROLMENT

School size	N	$\bar{X}$	SD	Mean Rank	U	p value
>1000 learners	6	4.92	2.26	4.83	8.00	0.4762
< 1000 learners	4	7.17	4.98	6.50		
TOTAL	**10**	**5.82**	**3.52**			

Note: Significance of difference was assessed by using the Mann-Whitney U test.

Table 45 shows that the average difference in increase in mean achievement between pre- and post-test scores for the six schools with enrolments of less than 1000 is 4.92%. The average difference in increase in mean achievement between pre- and post-test scores for the four schools with enrolments of more than 1000 is 7.17%. Schools with enrolments of over 1000 show the greatest gains, however, these figures may be misleading as the sample of schools is very small, and the table shows a non-significant difference between the average percentage increase of the two groups ($p<0.05$).

Differences in increases in mean achievement by teacher age

Variables for the teachers' ages were re-coded and classified into two groups, teachers aged 25-39 years, and teachers aged 40-59 years. Table 45 shows the differences in increases in mean achievement between pre- and post-test scores according to teacher age.

TABLE 46: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO TEACHER AGE

Teacher age	N	$\bar{X}$	SD	Mean Rank	U	p value
25-39 years	8	6.24	3.75	6.5	8.00	0.4970
40-59 years	3	4.18	1.93	4.67		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Mann-Whitney U test.

Table 46 shows that the average difference in increase in mean achievement between pre- and post-test scores for the eight teachers aged 25 – 39 years old is 6.24%. The average difference in increase in mean achievement between pre- and post-test scores for three teachers aged 40–59 years is 4.18%. The classes of teachers aged 25-39 years show the greatest gains, however, the table shows a non-significant difference between the average percentage increase of the two groups ($p>0.05$).

Differences in increases in mean achievement by teacher qualifications

Teachers qualifications were classified into three categories, teachers with Matric plus 3 years teacher training, teachers with Matric plus 3/4 years of teacher training, and teachers with a Bachelor's degree and teacher training. Table 47 shows the differences in increases in mean achievement between pre- and posttest scores according to teacher qualifications.

TABLE 47: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO TEACHER QUALIFICATIONS

Teacher qualifications	N	$\bar{X}$	SD	Mean Rank	χ^2	p value
M+3 tt	5	6.67	4.49	6.80	1.45	0.4843
M+4/5 tt	4	5.46	2.60	6.25		
B.Degree + tt	2	3.65	0.77	3.50		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Kruskal-Wallis test

Table 47 shows that the average difference in increase in mean achievement between pre- and post-test scores for the five teachers with M + 3 years teacher training is 6.67%. The average difference in increase in mean achievement between pre- and post-test scores for the four teachers with M + 4/5 years of teacher training is 5.46%. The average difference in increase in mean achievement between pre- and post-test scores for the two teachers with Bachelor's degrees and teacher training is 3.64%. Classes with teachers with teachers with M + 3 teacher training showed greater gains, however, the table shows a non-significant difference between the average percentage increase of the three groups (p>0.05).

Differences in increases in mean achievement by year of teacher's last formal academic qualification

The year of teachers' last formal academic qualification has been re-coded and classified into three groups, 1984-1990, 1991-1993, and 1994-1998. Table 48 shows the differences in increases in mean achievement between pre- and post-test scores by the year of teacher's last formal academic qualifications.

TABLE 48: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO TEACHER LAST FORMAL ACADEMIC QUALIFICATIONS

Last formal qualification	N	$\bar{X}$	SD	Mean Rank	χ^2	p value
1984-1990	4	5.87	2.12	7.0	2.30	0.3162
1991-1993	3	7.79	5.81	7.33		
1994-1998	4	3.90	1.66	4.00		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Kruskal-Wallis test

Table 48 shows that the average difference in increase in mean achievement between pre- and post-test scores for four teachers who achieved their last formal qualification between 1984-1990 is 5.87%. The average difference in increase in mean achievement between pre- and post-test scores for three teachers who achieved their last formal qualification between 1991-1993 is 7.79%. The average difference in increase in mean achievement between pre- and post-test scores for four teachers who achieved their last formal qualification between 1994-1998 is 3.90%. Classes with teachers who achieved their last formal qualification between 1991-1993 show the greatest gains. However, the table shows a non-significant difference between the average percentage increase of the three groups (p>0.05).

Differences in increases in mean achievement *by* teacher experience

Teachers' teaching experience has been classified into two groups, teachers with less than 10 years' experience, and teachers with more than 10 years' experience. Table 49 shows the differences in increases in mean achievement between pre- and post-test scores according to teacher experience.

TABLE 49: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO TEACHER EXPERIENCE

Teacher Experience	N	$\bar{X}$	SD	Mean Rank	U	p value
> 10 years	7	5.52	4.17	5.29	9.00	0.345
< 10 years	4	5.95	1.88	7.25		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Mann-Whitney U test.

Table 49 shows that the average difference in increase in mean achievement between pre- and post-test scores for seven teachers with less than ten years experience is 5.52°/x. The average difference in increase in mean achievement between pre- and post-test scores for four teachers with more than ten years experience is 5.94%. Data indicates that classes with teachers with more than ten years experience have slightly higher gains than classes with teachers who have less than ten years experience. However, the table shows a non-significant difference between the average percentage increase of the two groups (p>0.05).

Differences in increases in *mean achievement by teacher's attendance at PSP workshops*

Table 50 shows the differences in increases in mean achievement between pre and post-test scores according to teachers' attendance at the PSP workshops linked to the Learning Programme for the second term.

TABLE 50: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO TEACHERS' ATTENDANCE AT FOUR PSP WORKSHOPS

Attendance	N	$\bar{X}$	SD	Mean Rank	χ^2	p value
2 workshops	5	7.39	4.53	7.60	2.18	0.336
3 workshops	5	4.39	1.19	4.80		
4 workshops	1	3.57	-	4.00		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Kruskal-Wallis test

Table 50 shows that the average difference in increase in mean achievement between pre- and post-test scores for the five teachers who attended two of the four PSP workshops is 7.39%. The average difference in increase in mean achievement between pre- and post-test scores for the five teachers who attended three of the four workshops is 4.39%. The average difference in increase in mean achievement between pre- and post-test scores for the teacher who attended all four workshops is 3.57°/x. However, the table shows a non-significant difference between the average percentage increase of the two groups (p>0.05).

Difference in increases in mean achievement by teacher feeling prepared/ *confident* teacher

Table 51 shows the differences in increases in mean achievement between pre- and post-test scores according to how well-prepared/confident teachers felt to teach the Learning Programme.

TABLE 51: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO HOW WELL-PREPARED/CONFIDENT TEACHERS FELT TO TEACH THE LEARNING PROGRAMME

Confidence	N	$\bar{X}$	SD	Mean Rank	U	p value
Well-prepared/ confident	7	5.47	4.07	5.29	9.00	0.344
Somewhat prepared/ confident	4	6.03	2.23	7.25		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Mann-Whitney U test.

Table 51 shows that the average difference in increase in mean achievement between pre- and post-test scores for seven teachers who felt well-prepared/confident is 5.47%. The average difference in increase in mean achievement between pre- and post-test scores for four teachers who felt somewhat prepared/confident is 6.03%. Classes whose teachers felt somewhat prepared/confident showed slightly higher gains than classes whose teachers felt well-prepared/confident. However, the table shows a non-significant difference between the average percentage increase of the two groups (p>0.05).

Difference in increases in mean achievement by teaching as teacher's first choice of career

Table 52 shows the differences in increases in mean achievement between pre- - and post-test scores according to whether teaching was teachers' first choice of career.

TABLE 52: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO WHETHER TEACHING WAS TEACHERS' FIRST CHOICE OF CAREER

Teaching first choice	N	$\bar{X}$	SD	Mean Rank	U	p value
Yes	3	4.38	0.92	5.33	10.00	0.683
No	8	6.17	3.90	6.25		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Mann-Whitney U test.

Table 52 shows that the average difference in increase in mean achievement between pre- and post-test scores for three teachers for whom teaching was a first choice of career is 4.38%. The average difference in increase in mean achievement between pre- and post-test scores for eight teachers for whom teaching was not a first choice of career is 6.17°/x. Classes with teachers for whom teaching was not a first choice of career showed greatest gains. However, the table shows a non-significant difference between the average percentage increase of the two groups (p>0.05).

Difference in increases in mean achievement by whether teachers would change career if they *had* a choice.

Table 53 shows the differences in increases in mean achievement between pre- and post-test scores according to whether teachers would change career if they had a choice.

TABLE 53: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO WHETHER TEACHERS WOULD CHANGE CAREER IF THEY HAD A CHOICE

Change careers	N	$\bar{X}$	SD	Mean Rank	U	p value
Yes	4	7.40	5.28	6.75	11.00	0.570
No	7	4.70	1.48	5.57		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Mann-Whitney U test.

Table 53 shows that the average difference in increase in mean achievement between pre- and post-test scores for teachers who would like to change careers is 7.40%. The average difference in increase in mean achievement between preand post-test scores for teachers who would not like to change careers is 4.70%. Classes of teachers who indicated that they would like to change careers showed the greatest gains. However, the table shows a non-significant difference between the average percentage increase of the two groups (p>0.05).

Difference in increases in mean achievement by the number of books the teacher has at home

The number of books teachers had at home was classified into three groups, less than 100 books, 101-200 books, and more than 200 books. Table 54 shows the differences in increases in mean achievement between pre- and post-test scores according to the number of books the teacher has at home.

TABLE 54: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO THE NUMBER OF BOOKS THE TEACHER HAS AT HOME

Number of books	N	$\bar{X}$	SD	Mean Rank	X^2	p value
< 100	4	4.56	1.80	5.50	2.89	0.235
101-200	2	3.33	0.33	3.00		
> 200	5	7.51	4.26	7.60		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Kruskal-Wallis test

Table 54 shows that the average difference in increase in mean achievement between pre- and post-test scores for teachers who have less than one hundred books at home is 4.56%. The average difference in increase in mean achievement between pre- and post-test scores for teachers who have 101 - 200 books at home is 3.33%. The average difference in increase in mean achievement between pre- and post-test scores for teacher who have more than two hundred books at home is 7.51%. Classes with teachers who have more than two hundred books at home showed the greatest gains. However, the table shows a non-significant difference between the average percentage increase of the three groups.

8.1.2 Difference in increases in mean achievement by key classroom variables

Differences in increase in mean achievement by class size

Table 55 shows the differences in increases in mean achievement between pre- and post-test scores according to the size of the class

TABLE 55: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO THE CLASS SIZE

Class size	N	$\bar{X}$	SD	Mean Rank	x^2	p value
30-39	4	3.73	1.36	3.75	7.05	0.029*
40-49	4	8.86	3.85	9.50		
50+	3	4.04	0.83	4.33		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Kruskal-Wallis test
* p>0.05 (not statistically significant)

Table 55 shows that the average difference in increase in mean achievement between pre- and post-test scores for four classes with 30-39 learners is 3.73%. The average difference in increase in mean achievement between pre- and post-test scores for four classes with 40-49 learners is 8.86%. The average difference in increase in mean achievement between pre- and post-test scores for three classes with over 50 learners is 4.04%. Classes with 40-49 learners showed the greatest gains. Moreover, the table shows a statistically significant difference between the average percentage increase of the three groups.

Correlation between increase in mean achievement and average age of learners

Table 56 shows the correlation between increases in mean achievement between pre- and post-test scores, and the average age of the class. (The average age of learners in each class is based on learners' year of birth). Spearman's rank order correlation[24] test was used to measure the degree of relationship between the ranked average age of each of the eleven classes and ranked differences in increases in mean achievement in each class.

[24] The Spearman's correlation co-efficient is a non-parametric test which uses ranks instead of actual data values.

TABLE 56: CORRELATION BETWEEN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES AND AVERAGE AGE OF THE CLASS

TEACHER	AVERAGE AGE OF THE CLASS	MEAN ACHIEVE MENT	SPEARMAN'S RANK	p value
Teacher 1	14.72	5.38	0.009	0.979
Teacher 2	14.33	8.51		
Teacher 3	13.16	6.10		
Teacher 4	15.21	2.24		
Teacher 5	14.02	6.43		
Teacher 6	13.98	3.57		
Teacher 7	13.97	3.10		
Teacher 8	13.50	4.19		
Teacher 9	14.20	14.41		
Teacher 10	14.43	4.99		
Teacher 11	14.19	3.55		
TOTAL	**14.15**	**5.68**		

Table 56 shows a non- significant correlation between differences in increases in mean achievement between pre- and post-test scores and the average age of the class ($p>0.05$).

Differences in increases in mean achievement by number of Natural Science lessons missed

The number of lessons classes missed has been classified into four groups, no lessons missed, 1-5 lessons missed, 6-10 lessons missed, and more than 11 lessons missed. Table 57 shows the differences in increases in mean achievement between pre- and post-test scores according to the number of Natural Sciences lessons missed. However, it should be noted that, because some teachers reported that their schools are offering separate courses in the two different sciences at the Grade 7 level, the number of lessons reportedly `missed' was based on the overall number of lessons allocated for teaching `General Science.'

TABLE 57: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO THE NUMBER OF LESSONS MISSED

Lessons missed	N	$\bar{X}$	SD	Mean Rank	x^2	p value
0	1	6.10	-	8.00	1.55	0.671
1 – 5	2	4.78	0.84	6.00		
6 – 10	4	5.87	2.12	7.00		
11+	4	5.83	5.75	4.50		
TOTAL	**11**	**5.68**	**3.39**			

Note: Significance of difference was assessed by using the Kruskal-Wallis test

Table 57 shows that the average difference in increase in mean achievement between pre- and post-test scores for the class that missed no lessons is 6.10%. The average difference in increase in mean achievement between pre- and post-test scores for classes that missed 1-5 lessons is 4.78%. The average difference in increase in mean achievement between pre- and post-test scores for classes that missed 6-10 lessons is 5.87%. The average difference in increase in mean achievement for classes that missed more than 11 lessons is 5.83%. The table shows a non-significant difference between the average percentage increase of the four groups (p>0,05).

8.1.3 Summary of main findings on relationships between differences in increases in mean achievement between pre- and post-test scores for the experimental group and key school, teacher, classroom variables

Because of the small size of the sample of schools and teachers used in the study, the results reflected on the tables above must be treated with caution. Thus, non-significant differences were obtained for most of the analyses. This cannot be viewed as conclusive. Nevertheless, the data do provide an indication of trends for further investigation in a larger study using larger samples of schools, teachers and learners.

Finally, although *no evidence of a statistically significant relationship* between differences in learner achievement and any of the other sets of data on school, teacher and classroom variables emerged, the following data provides indications of trends for further investigation:

- Schools with enrolments of over 1000 showed the greatest gains;
- Classes with teachers aged 25-39 years showed the greatest gains;
- Classes with teachers with teachers with M + 3 teacher training showed greater gains than teachers with M+ 4/5 and B. Degrees plus teacher training;
- Classes with teachers who achieved their last formal qualification between 1991-1993 showed the greatest gains;
- Classes with teachers with more than ten years' experience had slightly higher gains than classes with teachers who had less than ten years' experience;
- Classes whose teachers felt somewhat prepared/confident showed slightly higher gains than classes whose teachers felt prepared/confident;
- Classes with teachers for whom teaching was not a first choice of career showed greatest gains;
- Classes with teachers who indicated that they would like to change careers showed the greatest gains; and
- Classes with teachers who have more than two hundred books at home showed the greatest gains.

8.1.4 Differences in increases between mean achievement and key variables in learner characteristics

Differences in increases in mean achievement *by gender*

Because of the larger samples, parametric tests (t test, 1-way Anova) were used.

TABLE 58: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO GENDER

Gender	N	X̄	SD	t	p value
Girl	197	4.42	10.92	0.77	0.442
Boy	173	5.34	11.98		

Note: Significance of difference was assessed by using t-test for independent groups

Table 58 shows that the average difference in increase in mean achievement between pre- and post-test scores for girls is 4.42°/x. The average difference in increase in mean achievement between pre- and post-test scores for boys is 5.34%. Data indicate that the greatest gains were made by boys. However, the table shows a non-significant difference between the average percentage increase of the two groups (p>0.05).

Differences in increases in mean achievement by learners aged 13 or younger and number *of* learners at age 14 and older

TABLE 59: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO LEARNERS' AGE

Age	N	X̄	SD	t	p value
13 years and younger	151	5.20	12.21	0.46	0.468
14 years and older	222	4.65	10.80		

Note: Significance of difference was assessed by using t-test for independent groups

Table 59 shows that the average difference in increase in mean achievement between pre- and post-test scores for learners who were thirteen years and younger is 5.20%. The average difference in increase in mean achievement between pre- and post-test scores for learners aged fourteen and older is 4.65%. Data indicates that 14 year olds and older perform less well in terms of increases in mean achievement. However, the table shows a non-significant difference between the average percentage increase of the two groups (p>0.05).

Difference in increases in mean achievement by number of books at home

The number of books learners reported having at home has been classified into five groups, 0-10 books, 11-25 books, 26-100 books, and more than 200 books. Table 60 shows the differences in increases in mean achievement between pre and post-test scores according to the number of books at home.

TABLE 60: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO THE NUMBER OF BOOKS AT HOME

Books	N	X̄	SD	F	p value
0 – 10	191	4.26	11.50	0.51	0.728
11 – 25	107	6.19	11.58		
26 – 100	45	4.76	12.22		
101 – 200	12	5.16	8.96		
200+	8	3.57	9.09		

Note: Significance of difference was assessed by using 1-way Anova test

Data on Table 60 indicated that learners who report that they have between 1125 books at home showed the greatest gains. However, the table shows a nonsignificant difference between the average percentage increase of the five groups (p>0.05).

Difference in increases in mean achievement by parents' educational levels
Parents' educational levels have been classified into five groups, completed primary school, completed secondary school, completed vocational training, completed university training, and 'don't know'. Tables 61 and 62 show the differences in increases in mean achievement between pre- and post-test scores according to fathers' (Table 61) and mothers' (Table 62) educational levels.

TABLE 61: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO FATHERS' EDUCATIONAL LEVELS

Education	N	$\bar{X}$	SD	F	p value
Primary	66	5.56	11.50	0.51	0.1974
Secondary	67	7.91	12.75		
Vocational	68	3.81	8.82		
University	69	4.49	11.99		
Don't know	70	3.83	10.81		

Note: Significance of difference was assessed by using 1-way Anova test

TABLE 62: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO MOTHERS' EDUCATIONAL LEVELS

Education	N	$\bar{X}$	SD	F	p value
Primary	81	4.41	9.61	0.466	0.760
Secondary	130	5.71	12.39		
Vocational	18	6.08	9.06		
University	45	3.39	12.29		
Don't know	97	4.45	11.49		

Note: Significance of difference was assessed by using 1-way Anova test

Data on Tables 61 and 62 indicated that learners who reported that their:
1. father's completed secondary school;
2. mother's completed vocational training

showed the greatest gains. However, the tables show a non-significant difference between the average percentage increase of the five groups (p>0.05).

Difference in increases in mean achievement by learners' perception of their own success in Natural Sciences (usually doing well in Natural Sciences)

Learners' responses to the statement that they usually do well in Natural Sciences has been classified into five groups, strongly disagree, agree, disagree, and strongly disagree. Table 63 shows the differences in increases in mean achievement between pre- and post-test scores according to their responses.

TABLE 63: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO LEARNERS' PERCEPTION

Response	N	$\bar{X}$	SD	F	p value
Strongly agree	59	6.21	12.13	0.98	0.398
Agree	281	4.94	11.36		
Disagree	19	4.01	8.29		
Strongly disagree	9	-0.53	10.49		

Note: Significance of difference was assessed by using 1-way Anova test

Data on Table 64 indicated that learners who strongly disagreed with the statement showed a negative improvement. In other words, their results tended to be higher in the pre-test than in the post-test. Learners who strongly agreed showed the greatest gains. However, the table shows a non-significant difference between the average percentage increase of the five groups (p>0.05).

Difference in increases in mean achievement by learner attitude towards Natural Sciences (how much they like/dislike Natural Sciences)

Learners' responses to question how much do you like/dislike Natural Sciences has been classified into three groups, like a lot, like, and dislike. Table 64 shows the differences in increases in mean achievement between pre- and post-test scores according to their responses.

TABLE 64: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO LEARNERS' ATTITUDE

Response	N	$\bar{X}$	SD	F	p value
Like a lot	159	5.27	11.14	0.50	0.603
Like	192	4.76	11.78		
Dislike	20	2.62	6.82		

Note: Significance of difference was assessed by using 1-way Anova test

Data on Table 64 indicated that learners who reported that they liked Natural Sciences a lot showed the greatest gains. However, the table shows a non-significant difference between the average percentage increase of the five groups (p>0.05).

8.1.5 Summary of main findings on relationships between differences in increases in mean achievement between pre- and post-test scores for the experimental group and key learner variables

Although no evidence of a statistically significant relationship between differences in learner achievement and any of the other sets of data on variables in learner characteristics emerged, the following may indicate trends for further investigation:

- the greatest gains were made by boys;
- 14 year olds and older performed less well in terms of increases in mean achievement;
- learners who reported that their fathers completed secondary school showed the greatest gains;

- learners who reported that their mothers had completed vocational training show the greatest gains;
- learners who strongly disagreed with the statement that they usually did well in Natural Sciences showed a negative improvement; and
- learners who reported that they liked Natural Sciences a lot showed the greatest gains.

8.2 Relationship between the attained curriculum and the implemented curriculum

The relationship between the implemented curriculum and the attained curriculum has been analysed in terms of the relationship between teachers' instructional practices and learners' learning outcomes as measured through learner achievement in TIMSS item tests, and through learner attitudes towards Mathematics as revealed in the questionnaires.

Data on the implemented curriculum revealed key variables in learners' opportunity to learn in terms of

a) the number of minutes of Natural Sciences lessons learners had in the second term;
b) each teacher's coverage of PSP Learning Programme through the use of the activities; and
c) the extent to which teachers were able to engage of learners with the Science concepts, processes and language to be learnt.

Differences in increases in mean achievement by number of minutes of Natural Science lessons

According to teachers' reports, under ideal conditions, learners in the sample of schools should have received 152 minutes of Natural Sciences lessons on average per week. However, problems with teaching and learning schedules at the schools did not allow for teachers and learners to teach and learn for the intended (ideal) number of minutes of Natural Sciences lessons.

Teachers' reports on the number of minutes of Natural Sciences lessons each class really had per week have been used in the analysis of differences in increases in mean achievement by the number of minutes of Natural Science lessons.

The number of minutes per week has been classified into three groups, 1.5 hours, more than 1.5 but less than 3 hours, and 3 hours and more. Table 66 shows the differences in increases in mean achievement between pre- and post-test scores according to the number of hours of Natural Sciences lessons per week.

TABLE 65: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO THE HOURS OF TEACHING PER WEEK

Minutes of hours	N	$\bar{X}$	SD	Mean Rank	χ^2	p value
1.5 hrs	2	3.65	0.77	3.50	3.27	0.195
>1.5 hrs but <3 hrs	4	8.15	4.64	8.25		
More than 3 hrs	5	4.52	1.64	5.20		
TOTAL	11	5.68	3.40			

Note: Significance of difference was assessed by using the Kruskal-Wallis test

Table 65 shows that the average difference in increase in mean achievement between pre- and post-test scores for the two classes that had 1.5 hours per week is 3.65%. The average difference in increase in mean achievement between pre- and post-test scores for the four classes that had more than 1.5 hours but less than 3 hours is 8.15%. The average difference in increase in mean achievement between pre- and post-test scores for five classes that had more than 3 hours is 4.52%. The table shows a non-significant difference between the average percentage increase of the three groups (p>0.05).

Differences in increases in mean achievement by teacher's coverage of PSP activities

Teachers' coverage of the PSP activities has been classified into four groups, 6 activities covered, 7 activities covered, 8 activities covered, and 10 or 11 activities covered. Table 66 shows the differences in increases in mean achievement between pre- and post-test scores according to the number of activities covered.

TABLE 66: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO THE ACTIVITIES COVERED

Minutes of teaching	N	$\bar{X}$	SD	Mean Rank	χ^2	p value
6 activities	2	3.21	1.38	3.00	3.69	0.296
7 activities	3	5.06	2.99	5.33		
8 activities	3	4.99	1.44	6.00		
10/11 activities	3	8.63	5.02	8.67		
TOTAL	11	5.68	3.39			

Note: Significance of difference was assessed by using the Kruskal-Wallis test

Table 66 shows that the average difference in increase in mean achievement between pre- and post-test scores for the two classes that covered 6 activities is 3.21 %. The average difference in increase in mean achievement between pre-and post-test scores for the three classes that covered 7 activities is 5.06°/x. The average difference in increase in mean achievement between pre- and post-test scores for three classes that covered 8 activities is 4.99°/Q. The average difference in increase in mean achievement between pre- and post-test scores for three classes that covered 10/11 activities is 8.63%. Thus the three classes that covered 10/11 of the activities showed greater gains than classes that only covered 6, 7 or 8 of the activities. However, the table shows a non-significant difference between the average percentage increase of the four groups (p>0.05).

Differences in increases in mean achievement by teachers' overall rating in terms of the criteria

The quantitative and qualitative aspects of the analysis of teachers' engagement of learners with Natural Sciences knowledge (content, concepts, language and processes) made it possible to explore the relationship between differences and similarities in teachers' instructional practices and differences or similarities in learner attainment in Grade 7 Natural Sciences classes.

Table 67 shows the differences in increases in mean achievement between pre- and post-test scores according to teachers' overall rating in terms of the criteria. Spearman's rank order correlation test was used to measure the degree of relationship between the ranked ratings for each teacher's classroom practice and ranked differences in increases in mean achievement in each class. However, the rating of Teacher Ts classroom practice has been excluded from the test. The reason for this is that, although this teacher's classroom practice was highly rated, indications were that Teacher Ts class had considerably less exposure to the teacher than any other classes whose teachers' practices ranked amongst the top six ratings. (The teacher reported that implementation of the Learning Programme at the school had been severely interrupted because the timetable had to be restructured after teachers had taken retrenchment packages, and because the teacher had suffered a personal bereavement.)

TABLE 67: DIFFERENCES IN INCREASES IN MEAN ACHIEVEMENT BETWEEN PRE- AND POST-TEST SCORES ACCORDING TO TEACHERS' OVERALL RATING IN THE CLASSROOM OBSERVATIONS

TEACHER	TEACHER'S RATING	MEAN ACHIEVEMENT	SPEARMAN'S RANK	p value
Teacher 1	48	5.38	0.887	0.001*
Teacher 2	50	8.51		
Teacher 3	53	6.10		
Teacher 4	32	2.24		
Teacher 5	55	6.43		
Teacher 6	29	3.10		
Teacher 8	42	4.19		
Teacher 9	60	14.41		
Teacher 10	44	4.99		
Teacher 11	44	3.55		
TOTAL	14.15	5.68		

Note: Teacher 7's results have been ignored for this rank order correlation
* p>0.01 (highly statistically significant)

Table 67 shows a highly significant correlation between differences in increases in mean achievement between pre- and post-test scores and the teachers' ratings in terms of the criteria. This indicates a close relationship between the ratings given to teachers through the use of the criteria and indicators on the observation instrument and differences in increases in learner attainment.

8.3 Resume

The study of the relationship between differences in increases between learners' mean achievement and key school, teacher and classroom variables revealed evidence of a statistically significant difference between average percentage increases in learners' mean achievement and the three groups of classes classified according to the size of the class. Classes with 40-49 learners showed the greatest gains. However, because of the relatively small size of the sample, non-significant findings cannot be viewed as conclusive. Nevertheless, the data provide an indication of trends for further investigation.

No other evidence of statistically significant differences between average percentage increases in learner achievement and any of the following sets of data on key variables emerged

- school enrolment (size);
- teacher age;
- teacher qualifications;
- by year of teacher's last formal academic qualification; • teacher experience;
- Natural Sciences specialist teacher;
- teachers' attendance at PSP workshops;
- teacher feeling prepared/confident teacher;
- teaching as teacher's first choice of career;
- teacher would change career is he/she had a choice;
- number of books the teacher has at home;
- average age of learners in class;
- number of Natural Science lessons missed; • gender;
- number of learners aged 13 or younger and no. of learners at age 14 and older;
- number of books at learner's home;
- parents' educational levels;
- learner perception of their own success in Natural Sciences; and
- learner attitude towards Natural Sciences.

Whilst data from the study of the relationship between the attained curriculum and the implemented curriculum indicated that

- the four classes that had more than 1.5 hours but less than 3 hours of Natural Sciences lessons per week made greater gains than classes that had less than 1.5 hours, or 3 or more hours per week; and
- the three classes that covered the most activities (10/11) made greater gains than classes that covered fewer activities,

statistical tests revealed no evidence of significant differences between average percentage increases in learner achievement and

- the number of activities covered between the pre- and post-tests; or
- the number of minutes of Natural Sciences lessons taught per week.

However, the study of the relationship between the attained curriculum and the implemented curriculum revealed a highly statistically significant correlation between differences in increases in mean achievement between pre- and post-test scores and the ratings of ten teachers' practices in terms of the criteria. In other words statistical tests provided evidence of a strong relationship between learner achievement in the item tests and the researchers' assessment of the extent to which teachers were able to engage learners with the Natural Sciences knowledge (content, concepts, processes and language) to be learnt.

Obviously, the results that emerged from the study of the relationship between the attained curriculum, the social and educational context for learning, and the implemented curriculum need to be treated with caution because of the small sample of schools and teachers used in the study. Nevertheless, the findings do suggest trends for further investigation through a larger study using bigger samples of schools, teachers and learners.

The study of the relationship between the attained curriculum, the implemented curriculum, and the social and educational context supports the view that classrooms are subject to many contextual variables. However, the findings of the Focus on Seven study also support the notion that, ultimately it is the quality of learners' engagement with Natural Sciences knowledge (content, concepts, processes and language) that is central to learner attainment.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

Data from this investigation into Natural Sciences teaching and learning at the Grade 7 reveals something about what an intervention such as the PSP Learning Programme is able to achieve in the context of urban ex-DET schools in South Africa.

The study of the *intended* curriculum revealed that the PSP Learning Programme together with its activities played an important role in structuring instruction and providing teachers with a context for achieving the outcomes of the new curriculum; in that:

- it was designed to
  a) `fit' the demands of Curriculum 2005;
  b) assist teachers to cope with implementing the new curriculum;
  c) develop the central theme *Earth and Beyond* from the Natural Sciences Learning Area;
  d) assist teachers to organise and pace their teaching to systematically cover the intended theme;
  e) assist teachers to sequence the core content of the theme coherently; and
  f) assist teachers in developing learners' communicative and academic language; and
- it provided teachers with
  a) explicit goals/priorities for their Grade 7 Natural Sciences teaching and learning in the second term of 1998;
  b) clarity about the concepts and skills to be developed in the Learning Programme; and
  c) curricular materials matched to the Learning Programme and designed to support classroom instruction.

The study of the implemented curriculum revealed that:

- the Learning Programme was in a sense the curriculum that guided the teachers' Natural Sciences teaching;
- the Programme's activities and curriculum material were the main, and in most cases the only resources used by the teachers in their Grade 7 Natural Science lessons;
- all the teachers' used PSP language-sensitive, activity-based, learner-centred methodology in their Natural Sciences teaching.

The study of the attained curriculum revealed:

- a highly statistically significant overall improvement from the pre-test to the post-test for the whole sample of learners;
- in eight of the eleven classes the improvement between the pre- and post-test was statistically significant, and
- that no classes showed a decrease in mean achievement between the pre- and post-tests.

All of the above provides evidence that interventions such as the PSP Learning Programme are making a valuable contribution and have the potential to benefit the school system.

However, the study of the implemented curriculum revealed that, in spite of the support provided by the Programme, the sample of Grade 7 Natural Sciences teachers still experienced difficulty in meeting the intentions of the Learning Programme and the demands of the new curriculum, because:

1. disruptions at schools and other interruptions in the teaching programmes made it impossible for teachers
   - to organise their teaching so that they covered all the intended activities; and
   - to develop the theme, *Earth and Beyond,* coherently *as* an ongoing narrative/story, rather than as a set of separate and unrelated activities;
2. teachers struggled to engage learners with Natural Sciences knowledge (content, concepts and processes) at adequate levels because
   - teachers themselves were under-prepared in the discipline/subject knowledge they were trying to teach, and were therefore not entirely in control of the subject matter; and/or
   - learners lacked both the necessary foundational knowledge (concepts, processes and language) in the Natural Sciences, and other foundational competencies (such as adequate reading levels) to meet the demands of the Learning Programme and the teachers' new teaching approach;
3. the information/guidance that appeared in the activities/curriculum material was insufficient to overcome the effects of
   - teachers' working conditions;
   - learners' inadequate foundational competencies/knowledge and skills; and
   - teachers' inadequate knowledge of the subject matter.

In other words, the study of the implemented curriculum revealed that, even the best teachers in the sample were constrained in their efforts to engage learners in the Learning Programme and its activities in the way that the new curriculum and the intervention wanted them to.

Furthermore, although the study of the attained curriculum provided evidence of an overall improvement of 5.96% across all eleven classes over the term:

- 40% of the total sample showed negative improvement or no improvement over the term; and
- only 10% of the sample showed improvement of 21 % and more;
- learner achievement in the majority of the items at the end of the term was still far below that of their international counterparts in the other countries that participated in the TIMSS.

Learners' incorrect responses:

- to open-ended questions showed little evidence of learners having moved beyond naive realist notions of the concepts/topics covered in the Learning Programme;

- to multiple choice and extended response items reflected common sense 'everyday' understandings as opposed to scientific conceptions, or revealed knowledge and understanding of general knowledge/concepts instead of more specific knowledge/concepts, or indicated that learners were operating with confused or fragmented knowledge/understandings of the topics/ concepts covered in the Learning Programme.

Further evidence from the study of the attained curriculum through the use of the Performance Tasks showed that the majority of learners still experienced difficulty in:
- reading and understanding simple instructions and in using more complex information or texts;
- constructing formal scientific models or representations;
- interpreting, organising and using scientific data;
- sharing information and communicating scientifically.

Thus a conclusion of this study is that, given the existing systemic and contextual constraints and conditions in urban ex-DET schools in South Africa, inputs such as the PSP Learning Programme:
- cannot alone finally determine what teachers teach and what learners learn;
- are unable on their own to transform the 'opportunity to learn' that the 'typical' learner in urban township schools in South Africa receives; and
- are unlikely to impact substantially on the quality of teaching and learning without additional contextual and systemic support.

A further conclusion is that we can no longer afford to ignore the constraints imposed on teachers in emphasising a more conceptual or process-based approach to teaching, and in engaging learners with Natural Sciences knowledge (content, concepts, processes, and language) at adequate levels in contexts where:
- conditions in schools cut short or interrupt the 'flow' of teachers' teaching programmes, and limit learners' 'time to learn' ;
- large numbers of learners lack foundational competencies and skills;
- resources such as materials and equipment are limited;
- teachers themselves have limited resources of subject knowledge to draw on in meeting the needs of learners spontaneously as they arise;
- classroom material/texts used by teachers are inadequate to meet the teaching and learning needs of teachers and learners.

In other words, we can no longer afford to ignore the obstacles:
- to teachers in meeting the demands of the new curriculum; and consequently,
- to learners making substantive learning gains.

9.2 Recommendations

Two questions emerging from the conclusions presented above are:

1. What contextual or systemic support would better

a) ensure the success of the new curriculum reform process by facilitating teachers' coverage of key content, concepts and processes in the Natural Sciences Learning Area at adequate levels; and also

b) assist INSET interventions (such as the PSP Learning Programme) to overcome the obstacles that presently undermine the impact that their work is having on the quality of teaching and learning?

2. What additional contextual and systemic support do interventions such as the PSP Learning Programme need to provide to teachers that will better enable them to emphasise a more conceptual and process-based approach to teaching in their working conditions. In particular, what kinds of support will best assist teachers in these contexts to overcome those factors that presently limit the quality of learners' engagement with key Natural Sciences content and processes, and consequently, the quality of learning outcomes.

It is with the above questions in mind that the recommendations that follow are made.

9.2.1 Contextual and systemic support at policy level

The Learning Programme used by the sample of teachers in the second term was both focused and structured in that it:

- was designed to develop the central theme Earth and Beyond from the Natural Sciences Learning Area; and
- it provided teachers with learning goals (concepts and skills) to be developed through the use of the activities/learning material.

However, the findings of the study revealed that, because of interruptions and limitations in teaching time in schools, coverage of the theme of the Learning Programme was fairly modest on average (teachers covered only 8 [just over half] of the 14 intended activities on average). This meant that some of key content/concepts were not addressed.

Evidence from this and other studies has revealed that 'time to learn' or 'time on task' is one of the most limited resources in the majority of urban ex-DET schools. The evidence indicates that, if the goal of improved learning outcomes is to be achieved, then critical contextual and systemic support or changes are required to:
a) facilitate and ensure teachers' coverage of key content and processes; and
b) assist INSET interventions to increase their impact .

Such support would involve

- the creation of more effective and supportive teaching and learning conditions in schools; and
- strategies for ensuring that teaching and learning time in schools is used more efficiently and purposefully by teachers and learners.

Suggested strategies for achieving these goals include developing:

- a curriculum framework that makes all schools and teachers' accountable for ensuring that all learners are provided with the opportunity to at least cover a core of key Natural Science content (knowledge, concepts, and processes);
- incentives for schools and teachers to at least 'get the basics right'. For example, through rewards for significant improvement in learner performance, and for maintaining high achievement levels;
- internal and external mechanisms that would enable schools and teachers to measure or assess whether their learners are performing at appropriate levels. For example, through the development and use of graded assessment tasks (exemplars of what learners should be able to do with key content) designed to establish whether learners are actually performing at appropriate levels.

9.2.1.1 Clearly-defined content goals

Curriculum 2005 provides an overarching vision of what the Natural Sciences Learning Area should be. However, although Curriculum 2005 documentation provides broad 'themes' that can be covered in the Learning Area, the official documents do not make the key content/topics to be covered explicit. The findings of this study indicate that the information presently available in the official documents is inadequate given the kinds of conditions that exist in the majority of township schools in South Africa, and that extra information is required.

In particular, the findings indicate that the kind of contextual, or systemic support that would facilitate teachers' coverage of key content and processes, (and that would assist INSET interventions to increase their impact) involve the development of clearly-stated content goals that schools and teachers can deliberately strive to achieve.

At present Natural Sciences educators and organisations involved in the teaching of Natural Sciences are uncertain about what content and processes they should include and what content and processes they should leave out of their Learning Programmes. In their attempts to be inclusive, they may either attempt to cover too many topics, or they may omit crucial content/processes in their Learning Programmes. Furthermore, because there is little co-ordination in terms of the content/processes covered by individual teachers, schools and/or interventions across the different grades/phases, many learners may not be acquiring the necessary foundational Natural Sciences knowledge, understandings, skills and language for teachers at the higher levels to build on.

Thus, a recommendation of this study is that official curriculum documents provide the key Natural Sciences knowledge (content and processes) to be covered in each particular level and/or phase.

9.2.1.2 Graded assessment tasks

Curriculum 2005 documentation does not make explicit the levels at which teachers in the different grades are required to cover Natural Sciences knowledge. In other words, what actually counts as an outcome or competency for the various grade/phase levels is open to different interpretations by individuals and organisations.

The development and use of graded assessment tasks would enable teachers and schools to measure the level of their learners' competence against expected/ acceptable standards of performance, and would assist teachers in ensuring that:

a) they are addressing the curriculum goals at adequate levels of complexity, and
b) their learners are able to perform at appropriate levels. (The assessment tasks could provide guidance to teachers through the inclusion of examples of how learners might answer if they do or do not have the concepts.)

A recommendation of this study is that graded assessment items/tasks for each of the knowledge goals at the different levels are developed so that they can serve as tools for:

- establishing whether learners have attained the necessary foundational competencies (knowledge of subject matter, language, understandings, processes and skills) for particular levels;
- assisting teachers to ensure that they are making satisfactory demands on learners; and
- assessing learner performance against expected standards of performance at the different levels.

9.2.2 Contextual and systemic support from interventions

Data from this study indicates that interventions such as the PSP Learning Programme would be more effective if teachers were provided with additional systemic and contextual support in the form of:

- teacher development, in particular INSET directed at developing teachers' own discipline knowledge and understanding of the subject matter they are expected to teach (see 9.2.2.1);
- learning programmes that focused on achieving a few strategic goals and that assist teachers to develop concepts and processes in terms of incremental complexity (see 9.2.2.2);
- curriculum material/texts carefully designed to help teachers by `closing the gap' between teachers' inadequate subject matter knowledge and the curriculum goals, thus assisting teachers to engage learners with key knowledge (content, concepts, processes, and language) at appropriate levels (see 9.2.2.3).

9.2.2.1 Teacher development

Evidence from the study indicated that teachers are not entirely in control of the Natural Sciences subject matter and that teachers themselves need to master the subject matter they are to teach. The findings suggest that INSET that focuses on broadening and deepening teachers' knowledge of the subject would enable teachers to engage learners with Natural Sciences content and processes more spontaneously and at more appropriate levels.

The findings also suggest that interventions need to focus on assisting teachers:

- with paying much more careful attention to how concepts and processes are presented and developed in the language used in their teaching; and
- to use and employ curriculum material more appropriately and effectively

9.2.2.2 Learning programmes

Evidence from the study suggests that learning programmes need to be designed to provide learning experiences that:

- are highly focused on achieving fewer well-defined and highly strategic goals (rather than trying to provide learners with integrated learning experiences that are inclusive at the expense of achieving coherent conceptual/content goals); and
- address content cumulatively in terms of increasing cognitive complexity, so that learners can practice using concepts/processes/skills/language in progressively difficult ways (for example, through the use of graded readings/texts; sequencing/comparing two pieces of information, three pieces, four, or more pieces of information etc.), and so that teachers can build on previously learnt concepts, knowledge and skills.

In other words, findings suggest that learning programmes need to be skilfully designed around a graded series of progressively complex contents and processes that are developed in a sequential way.

9.2.2.3 Curriculum material

The Focus on Seven study showed that the PSP activities played an important role in structuring instruction, and that it is essential that such instructional material be very carefully designed.

The findings suggested that the curriculum material would have been more effective if:

- the core knowledge (content, processes, and language/vocabulary) to be learnt were made much more explicit in the curriculum material; and
- more careful attention was paid to the kinds and levels of language used in the classroom texts provided.

The findings also indicated that the material could be more effective if it included strategies for:

- establishing whether the necessary related foundational language and understandings/conceptions and skills are in place;
- assisting learners to decode and interpret simple and more complex, extended texts/scientific representations;
- deliberately developing the conceptual language learners need to communicate their scientific conceptions;

- using differences between learners' everyday and/or existing scientific conceptions/language/discourse and new conceptions/language/discourse to assist learners' to understand new Natural Sciences knowledge;
- moving learners towards a higher level of understanding or thinking through questioning formulated both to challenge learners' current thinking and to impel learners to generate questions;
- ensuring that learners are given more immediate feedback on their work; and
- assessing whether learners have really learned what they were meant to learn.

9,3 Research

Finally, the Focus on Seven investigation also raised some interesting areas for further research. In, particular, the study indicates a need for more systematic empirical research into what kinds of interventions work best in particular contexts. More especially, research into the kinds of interventions that are most effective in contexts where: -

- large numbers of learners lack foundational competencies and skills;
- children of working class backgrounds have to learn in a second or third language;
- conditions in schools limit learners' `opportunity to learn';
- school resources such as materials and equipment are limited; and
- teachers themselves have limited resources of subject knowledge to draw on in meeting the needs of the curriculum.

Thus, the study suggests a need for research into what types of interventions can be empirically demonstrated to produce the best outcomes for particular groups of learners, with particular types of teachers, in particular kinds of schools. Such research would entail the construction of highly particularised, generic models for Natural Sciences teaching and learning that can be tested in practice.

This research could eventually produce learning programmes tailored to meet the needs of learners and teachers with particular knowledge bases and/or experience in specific contexts. However, such programmes would need to be systematically designed to assist the greatest number of learners in these contexts to attain the best or most desirable results given the time and resources available for teaching and learning.

Other interesting areas for further research linked to the above are:

1. Research that analyses the relationship between teachers'
   - subject matter knowledge; and
   - teaching of the particular subject matter.

For example, the study revealed that, even when teachers were using the same activities, there was much variation in the quality of teachers' engagement of learners with the Natural Sciences knowledge (content, concepts, processes and language). Thus an area for future research could be investigating the extent to which teachers' own understandings/knowledge is related to the level of their engagement of learners with the Natural Sciences content and processes to be learnt. (In other words, an investigation into the extent to which teachers' knowledge of the subject matter guides or determines their practice.)

Such research could also help to establish causal links for some teachers benefiting more from some interventions than others.

2. Research into the development of appropriate test items that establish:

   a) Grade 7 learners' knowledge and ability in the Natural Sciences Learning Area;

   b) the positive effects of teachers' classroom practices on learner achievement in particular contexts.

   The Focus on Seven study revealed statistically significant evidence of improvement in learner achievement overall. However, it is highly likely that there were other qualitative effects of teachers' teaching on learners' learning that were not revealed through the use of the TIMSS items. Different types of tests would make it feasible to look at the long-term effects on learner's learning by measuring learning retention over time by re-testing learners.

3. Research into the kinds of material that is most effective in terms of developing key content, concepts and processes in the Natural Sciences, given the social and educational context of `typical' ex-DET schools.

In conclusion

The role of the Focus on Seven researchers has been to plan and conduct appropriately designed empirical research, study the data, describe and report the findings and, make recommendations based on these findings. The researchers hope that the findings presented in this report will contribute to the ongoing educational debates in South Africa.

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