

**A REPORT ON SOME TESTS OF STANDARD 6 PUPILS' PERFORMANCE IN  
GENERAL SCIENCE AT A KWAZULU-NATAL SECONDARY SCHOOL,  
SOME POSSIBLE CONTRIBUTORY FACTORS, AND IMPLICATIONS FOR  
TEACHERS.**

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## DECLARATION

I, BEVERLEY ANN DAMONSE, declare that “ A report on some tests of standard 6 pupils’ performance in General Science at a KwaZulu-Natal secondary school, some possible contributory factors, and implications for teachers,” is my own work and that all sources I have used have been indicated by means of a complete bibliography.

Signed: *B.A. Damonse*

Pietermaritzburg, 1996.

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## **ABSTRACT.**

This research made a diagnostic assessment of some aspects of pupil performance in General Science on entry to secondary school. This assessment included written content and skills assessment of all standard 6 pupils at a secondary school in KwaZulu-Natal.

The written skills assessment of 302 pupils involved two tests, one in English and one in Zulu. General Science in the research school was taught in English, while two-thirds of the standard 6 pupil population had Zulu as their first language. All pupils first wrote the test in English, and then the Zulu pupils took the same test again in Zulu. The test was designed to assess pupil performance in areas of a) symbolic representation of data b) application of science concepts c) interpretation of data and d) planning of investigations. The questions used in the test were adapted from the question bank of the Assessment of Performance Unit in the United Kingdom.

The written content assessment was designed to test pupils' understanding of various science concepts encountered in primary science. Their recognition of various pieces of science equipment was also tested.

Questionnaires regarding various aspects of science, science teaching practice and perceptions of pupil abilities were administered to pupils' past (standard 5) and present (standard 6) science teachers. A focused group discussion with science teachers at the research school investigated some thoughts on skills-based teaching and assessment. The

researcher was also able to draw on experiences of classroom observation as she is a teacher at the research school.

As hypothesised, pupils' performance in the skills tested was generally poor, especially in the skills more specifically related to science. Content assessment revealed that almost half of the pupils in the classes analysed held common misconceptions about certain science concepts, not unlike those held by primary school children tested in other countries. Pupil performance generally increased when pupils were presented with a test in their mother-tongue. In other areas, e.g. planning of investigations, poor performance in both English and Zulu tests indicated that these questions were either not known or understood, rather than an issue of linguistic difficulty. Teachers highlighted several factors which retarded the progress of skills-based teaching methods in 'real-life' classroom situations.

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## **CHAPTER ONE**

### **DEFINING THE PROBLEM**

#### **1.1. INTRODUCTION**

“The content of school science, unlike history, geography or language teaching, has suffered little ideological distortion specific to apartheid. The fact that it has remained undistorted is precisely because it has been so decontextualised” (Kahn and Rollnick 1993, p.269). This situation is surely testimony to the survival of a historically elitist system which “fossilised its concerns on academic rationalism” (Macdonald 1993, p.15).

The science education structure adopted in pre-independence South Africa (pre-1994) was one in which a single subject at junior secondary level, general science, was followed at senior secondary level by two separate subjects, namely physical science and biology. The choice of content in these latter two subjects has been largely driven by the requirements of first-year university courses, and the subjects have been characterised by a strong emphasis on theory and a near total neglect of the issue of context. Neither of these two subjects has been compulsory for the joint Senior Certificate and matriculation examination taken at the end of year 12. Some basic data regarding the school system shows the following disturbing statistics: “...in all there are some 10 million learners in 23 000 schools taught by some 300 000 teachers. A mere 90 000 students take the Senior Certificate examinations in Physical Science and Mathematics, and of these some 60 000 pass. Of the latter, barely 3000 are from the majority communities, and their rate of attainment of matriculation exemption is sixty times lower than for the minority” (Kahn 1995, p.443). Thus the scientific needs and interests of a substantial majority of

matriculants have been catered for only by general science, a compulsory subject consisting of roughly equal proportions of the physical and life sciences (Spargo 1995, p.30). It is hard to imagine how these scientific needs and interests would be met by a system fraught with educational, political and economic tensions. According to the 1994 Policy Framework on Education and Training of the African National Congress, science and mathematics teaching has been characterised by a 'cycle of mediocrity' manifested by the following:

- poor infrastructure for science teaching;
- lack of labs and equipment;
- underqualified teachers who are poorly prepared and
- an academic, outmoded and overloaded curriculum (ANC 1994, p.68).

Newly democratic South Africa has heralded a number of significant changes especially in the field of education. At the macro level, emerging policy alternatives have set goals for science and mathematics education, "aiming to provide a quality educative experience by reconstructing the entire curriculum" (Kahn 1995, p.446). At the micro level, this dynamic period of curriculum transition has translated into the multilingual, multicultural classroom where once traditionally taken-for-granted classroom practices are no longer viable.

## **1.2. SITUATIONAL OVERVIEW**

Against the background information provided, let me now place the research in local context by providing a description of the conditions prevalent at the school where the

research was carried out. Up until 1994/5 the school was administered by the House of Representatives and this fact ensured that under the old dispensation the school was fairly well resourced for science teaching. The school has 5 laboratories and enough equipment for demonstrations at least, and when pupil numbers were lower, some group work practicals. With careful planning and consultation with other colleagues, access to overhead projectors, a television set or video machine is possible. All science teachers actively teaching the subject have science teaching qualifications and experience. General Science teaching has been guided (or ruled) by the official syllabus and in particular by adherence to the strict assessment procedures outlined therein. "A strong pressure in science learning is the need to teach the testable knowledge dictated by the examination" (Peacock 1995, p.154).

Apartheid policy enforced divisions along racial and linguistic lines which, until approximately 1993, ensured that pupils entering standard six were drawn chiefly from local 'coloured' primary schools. Each classroom was an almost monolingual, monocultural cocoon - a homogeneous unit where the chances of conflict, and probably of change, were minimal. The assumption was that a pupil who had progressed from one of the local schools had been taught the prerequisite standard five general science syllabus in fairly well resourced schools, generally by qualified teachers. The task of the standard six science teacher then was to 'continue' where the primary school had left off. This ties in with what is called the resumptionist approach to curriculum continuity where the view held is that "the secondary school should 'build on' primary science, continue from where the primary school had left off - no repetition" (Jarman 1995, p.147). The strong underlying assumption was that the incoming pupil population shared a common science

background and primary science experience. This traditional practice was seriously challenged when the strict school admission policies were initially relaxed (1992/93) and finally removed (1995) to allow the movement of pupils of all race groups to schools of their choice. Many pupils from previously black schools then entered standard six classes at the research school.

In 1993 the school started a "Language Integration Programme" (LIP) to cater mostly for English second language pupils. This programme was designed to help develop the English language skills needed to cope with learning in a school using English as the medium of instruction. The LIP assumed that the pupils' performance in their other subjects would be directly dependent upon their performance in English.

This programme was based upon a thematic approach to teaching, emphasising English across the curriculum. The subjects included at first were English, Afrikaans, Mathematics, History and Geography. It is very interesting to note that General Science was attempted in the programme but not many of the sections initially planned were completed. This was suggested to be mostly due to the fact that teachers in the programme who were not trained science teachers did not feel confident about teaching the content of the general science syllabus. "The problem of pupils' learning by rote may be exacerbated when the teacher is insecure in his or her science knowledge" (Goodwin 1995, p.101). Newton (1988) feels that teacher specialism is also a culprit in this regard: "Science teachers are not usually 'generalists'. They are seen as experts in a specific body of knowledge" (Newton 1988, p.87).

In subsequent years (1994 and 1995) it was felt that the pupils should be taught some science, but that this would be best accomplished by one of the science teachers within the department at the time. The emphasis however was still on the development of English, so only 2 periods of General Science per 7-day cycle were allocated. This time was considered to be absolutely minimal, in which very little of the prescribed content could be covered. Development of language and communication skills were paramount and since assessment was internal, the necessary adjustments could be made to assessment procedures which were once not negotiable. However, in 1995 the official notification of the introduction of the new General Education Certificate Examination, possibly to be written for the first time at the end of 1997, provided the impetus for change once again. This examination will be a national examination completed by all pupils at the end of year 9 (standard 7). It is intended to provide a departure point for different learning pathways within the integrated education and training system.

It is stated that “the GEC, as the first formal evaluation point in the education and training system, will seek to assess comprehension, analytical and problem-solving skills as well as the ability to communicate, plan and design investigations” (Gordon, Snell, Pahad and Nokwe 1995, p20). It is also envisaged that a student who has successfully completed the GEC should have the following science and technology abilities (Rollnick and Perold 1995, p.119).

- The ability to discuss and explain key concepts in science and technology.
- A demonstrable capacity to:
  - a) investigate, analyse and understand problem situations;
  - b) plan and design sound and feasible solutions;

- c) assess and report outcomes and make adaptations;
  - d) observe, explore and order their observations;
  - e) handle basic science apparatus.
- The ability to describe and discuss issues and consequences related to the useful application of science and technology.
  - An elementary awareness of basic constraints such as design, safety, cost, aesthetics, material properties, ergonomics and environmental impact.
  - The ability to describe in simple terms the basic processes involved in the production and distribution of basic resources such as water and energy, and industries such as mining, agriculture and communication.
  - The ability to work in a team.
  - The ability to communicate matters of a scientific and technological nature verbally and in writing and the ability to gather data and process information.
  - An understanding of broad career fields and further studies opportunities in science and technology and the ability to discuss these in relation to his or her personal level of interest and strengths and weaknesses.
  - An ethical and moral attitude towards the use of science and technology and its consequences for South Africa.
  - Respect and concern for all life and the environment, and the ability to analyse and possibly provide solutions to health, environment and development problems.

This certainly represents a more holistic view of science than previously stated in science syllabi and has major implications for teachers, pupils and classroom practice. A guideline document for general science teachers supplied by the Kwazulu-Natal

Department of Education and Culture states that the examination “will focus on the skills and processes in the aims and objectives of the syllabus” (Kwazulu-Natal Department of Education and Culture 1996, p.2). The immediate stress is now on what is loosely termed “skills based assessment”, although the interpretation of this amongst teachers is varied. What is recognised however, is that there is an attempt to shift away from an emphasis on rote learning and familiar routines to a stated emphasis on the development of critical thinking, reasoning, reflection and understanding. “We need an education system oriented towards the future, which promotes the pupil’s initiative and independence, arouses his interest and motivates him to continue to study, trains him in creative thinking and problem-solving and, above all, teaches him to make use of the already extensive resources of ‘parallel education’, including those of the mass media” (Kupisiewicz 1984, p.13).

Following the announcement of the new GEC at the research school, preparation for examinations once again exerted some pressure, with teachers immediately focusing on changes that would allow them maximum time to prepare their students for this formal evaluation. In 1996 the number of General Science periods in standard six was increased to 5 periods per 7-day cycle.

Increased time allocation for science teaching is but one aspect of a rather complex situation. The pattern of enrolments in school exercises so much potential effect on the selection and ordering of material that it is surprising that it causes so little apparent concern to curriculum planners. Hawes (1979) mentions a number of factors, any or all



of which can or should exert considerable effect upon curriculum planning. The factors are listed as:

- early or late age of entry;
- mixed or homogenous age groups;
- high or low drop-out rates, repeating or transfers in from other schools;
- homogeneous or mixed language ethnic groups;
- sex equality or sex imbalance;
- high or low numbers in class;
- high, low, regular or irregular attendance at school.

“A cruel generalisation, but probably justified, would be to suggest that the large majority of curricula in Africa are designed for an ideal situation - namely a uniform six year old entry, relatively homogenous in age and culture, equal in sex and of average size (say 30 - 45 in a class) who attend regularly, repeat seldom and complete their primary course. Yet such a situation seldom exists” (Hawes 1979, p.14).

The actual situation at the research school is much more complicated. For the standard six General Science teacher at this school (and probably many others as well) the challenges that exist at this level are multidimensional.

Pupils admitted to standard six in 1996 were drawn from approximately 100 different primary schools. These feeder schools are a mixture of urban and rural schools, with the science taught and learnt, resources etc. differing for each school, even for schools within one of the formerly racially - based educational departments (KZ, DET, HOR). Children thus bring very different types of primary school science experience to the secondary

school. Many of the pupils have experienced a primary education seriously affected by the socio-political and economic constraints fostered by apartheid education. Teachers involved in science in-service programmes have cited some of the following problems (Urban Foundation 1991, p.33):

- The unrest in our schools affects the smooth running of classes and has left a nasty psychological impact on the minds of our youngsters.
- The exodus of staffing of teachers is another factor which retards progress. It is quite common for science teachers to be changed every year.
- Large class groups cannot be handled and inhibit progress and encourage the demonstration method.
- Shortage of physical resources for science teaching.
- Though pupils understand the experiments well, they lack the flair to express themselves in English as the medium of communication.
- There are also factors which are beyond the control of the science teacher, but which directly affect the pupil in the classroom. These include unemployment, communities with impoverished homes, high rates of illiteracy, and no electricity or running water.

Another important factor in the research school is that almost 85% of the pupils in standard six are Zulu speaking with English as their second language. The medium of instruction in the school is English, and the science teachers employed at present are not fluent in Zulu. The fluency of pupils in English is very varied, even within the same class. By their own admission, pupils speak English only during formal teaching time, with all other communication carried out in the mother tongue. Language of instruction is a controversial issue in many countries, and in science this is complicated by the

terminology requirements and the conceptual problems between the vernacular languages and the language of teaching. The primary science experiences of many of these pupils have also been affected by the fact that “many primary science teachers are ineffective teachers of science because their own difficulties in English have prevented them from fully understanding key science concepts” (Peacock 1994, p.362). Texts available in the school for student use are still those written by non-speakers of the vernacular languages and so seldom take account of the linguistic difficulties presented to learners of science.

The children entering standard six in 1996 comprise those who have progressed from standard five, many who are repeating standard six, some who were in standard seven in former Black schools as well as a few who have had their schooling interrupted for personal and or political reasons and so did not attend school in 1995. This also means that within the same standard are children of different ages (13 to 23 years old), while the average age of the present standard 6 pupils is 15.2 years.

The GEC presently looms as a serious threat to teachers faced with children who, across racial boundaries, are known to have had primary science experiences based to a large extent on rigid teaching and the dominance of “recall type examinations”. The prescribed general science syllabus can no longer automatically be taken as the starting point for science teaching in standard six. The levels of science content and basic skills are so varied that the general science teacher spends a large percentage of time teaching (or reteaching) concepts and or processes that she/he can no longer assume have been taught in primary school. Faced with this situation in the classroom, the question a teacher may be asking is: ‘Science in schools: which way now?’.

It is evident that schools are experiencing the tensions inherent in situations of change and curriculum reconstruction. Table 1 (page 12) outlines these tensions and places them in the context of school science today. Changes in the primary aims and objectives of science and the kinds of teaching-learning interactions within the classroom will have to be carefully understood by both teachers and pupils. We should start by considering the pupils themselves. It is necessary to find out what science content the pupils have learned. Teachers need to assess their abilities in certain scientific processes considered relevant for their stage of development. In doing this teachers will also need to be mindful of the role of language in affecting performance. It is only when the teachers have a realistic view of the science capabilities of the standard six pupils on entry to this secondary school that they can make informed decisions about meaningful change within the school science programme.

Curriculum changes and the planning necessary to achieve them originate at a number of points, yet in every instance one of the most basic processes involves “gathering basic information about the context in which the changes are to take place and about their feasibility. For unless we know where we are we cannot plan a course of action” (Hawes 1979, p.33).

TABLE 1. TENSIONS IN THE CURRICULUM DEBATE (from McNaught 1994, p.122)

<b>PHILOSOPHY OF SCIENCE</b>	
<u>Current convention.</u> Science is about facts	<u>New Ideas</u> Scientific theories are provisional and relative
Objective, apolitical and value free. The way of describing reality	Socially constructed One way of understanding our environment
<b>SOCIETY</b>	
<u>Current convention</u> Academics set the curriculum Certification Competition Schools isolated from the community	<u>New Ideas</u> Community involvement Quality of education Cooperation Workplace input into education
<b>CHILDREN'S LEARNING</b>	
<u>Current convention.</u> Child as receiver of knowledge  Children are empty vessels	<u>New ideas</u> Child constructs meaning with teacher support Children bring their own conceptions
<b>CONTENT</b>	
<u>Current convention</u> Facts dominate the syllabus Syllabuses are long Fragmented	<u>New ideas</u> Skills and processes dominate Syllabuses are shorter Integrated

The areas of science to be assessed are generally considered to include knowledge of facts and concepts, science process skills, science thinking and problem-solving skills, skills needed to manipulate laboratory equipment and the disposition to apply science knowledge and skills (Doran et al.1994, p.395). While it is recognised that a complete,

and indeed more detailed picture of actual capability should include assessment of all the above mentioned categories, the present research limits investigation to certain areas.

The aim of this research then may be stated as follows: to assess some of the basic science competencies (knowledge and skills) of standard six pupils on entry to a secondary school in an urban area in KwaZulu-Natal.

Through an analysis of pupil performance the researcher, where possible, would like to achieve the following:

- identify particular areas of strength common to the group;
- identify areas of common weakness;
- identify any misconceptions or alternative frameworks held by pupils in some primary science areas;
- determine the extent to which language affects written performance of second language learners at this interface between primary and secondary school.

Pupil performance will be related to primary science experiences (consultation with standard 5 teachers) and secondary science teaching practice (consultation with secondary school science teachers).

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1. INTRODUCTION

It is the contention of Harlen and Osborne (1985) that the teacher's view of learning and knowledge determines what happens in the classroom and profoundly constrains what becomes available to be learned. The way that teachers teach science may be linked to the science teacher's understanding of science. Nott and Wellington (1993) go so far as to suggest that teachers should be prepared to articulate their understanding of the subject they teach, to critically consider the image that they have of science and thereby become conscious of the impact this makes on classroom activity..

#### 2.2. VIEWS OF THE NATURE OF SCIENCE

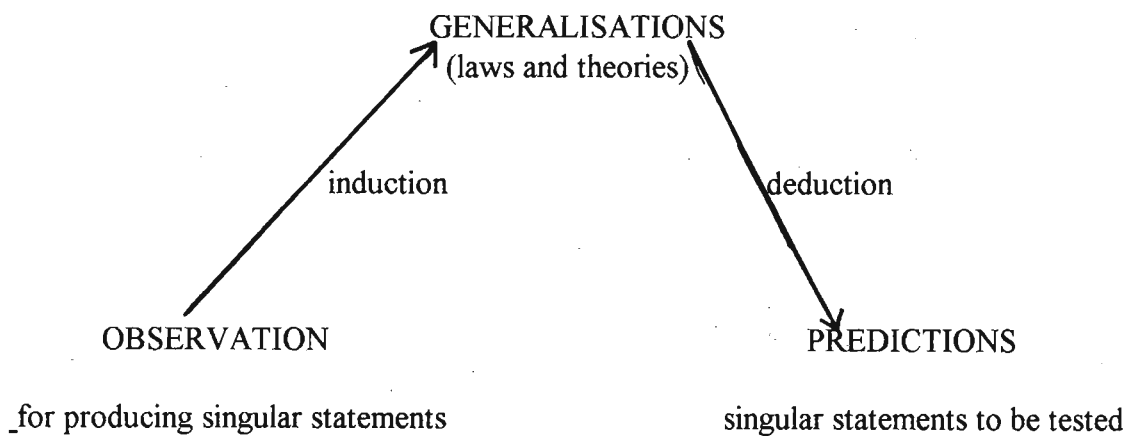
What are the views of the nature of science that may be held by teachers (this researcher included), and through their teaching, by their pupils as well?

##### 2.2.1. THE TRADITIONAL VIEW

The traditional view of the scientific enterprise asserts that science begins with simple, unprejudiced observations. The suggestion was that it was possible to observe a sufficient number of particular cases and then to generalise, either to some simple lawlike statement, or to some theory. Scientific laws are reached by a process of induction from the 'facts' of sense data (Driver, 1983 p.4). This view of science, represented in diagrammatic form by Hodson (1986) in Figure 1 below, has dominated science

education and many curriculum reforms. “This inductivist position was criticised when it was first suggested by Bacon nearly 400 years ago, yet it has reasserted itself early in this century in the heuristic movement and later in some of the more naive interpretations of the discovery method adopted by the Nuffield science schemes” (Driver 1983, p.4). In the Nuffield schemes the intention was that pupils should be encouraged to discover science for themselves. “The focus was on scientific method and objectivity with an underlying assumption that the pupil had no preconceptions, so that all observations were perceived as neutral” (Gott and Duggan 1995, p.18).

Figure 1. Traditional view of scientific method. (Hodson, 1986 p )



In this context, science itself is seen to have the following characteristics (Hodson, 1986):

1. It gives access to factual truths about the world.
2. Its knowledge is derived directly from the observation of phenomena.
3. It rationally tests its propositions by means of objective and reliable experimental procedures.
4. It is a neutral activity untainted by socio-historical and economic factors and produces value free knowledge.



This description probably does not differ much from the lay person's image of dispassionate scientists proceeding systematically towards objective truth. In the South African education system, with its legacy of a transmission mode of learning emphasising recall of facts, it is very likely that these myths about science have been internalised by teachers (this researcher included) during their own science education, and, in turn, represented to children through the curriculum. The dominance and almost unquestioning acceptance of the 'official syllabus' and the science textbooks in use in schools, is also largely due to this view of a neutral body of facts. The traditional view is now largely discredited because of its insistence on the validity of theory free observations and its acceptance of the principle that outcomes can be confidently predicted from hitherto consistent findings (Willig 1990, p.72). As Hodson (1986) suggested, the traditional view must be challenged in school science by making children aware that observations do not provide a secure basis of fact, do not constitute the starting point for science, and cannot be theory independent. The major impetus in the adoption of the discovery learning methods seems to be in the fusion of inductivist ideas about scientific method with progressive child-centred views about education. Driver (1983) talks about the 'intellectual dishonesty' of this approach, because "on the one hand pupils are expected to explore a phenomenon themselves, collect data and make inferences based on it: on the other hand this process is intended to lead to currently accepted scientific laws or principles" (Driver 1983, p.3).

### **2.2.2. THE HYPOTHETICO-DEDUCTIVE MODEL**

This is seen as an alternative to the much criticised traditional view. This method is thought to combine an active imagination with rigorous methodology. Popper (1972)

characterises this as “the method of bold conjectures and ingenious and severe attempts to refute them” (Popper 1972, p.81). Theories are not related by induction to sense data, but are constructions of the human mind whose link with the world of experience comes through the processes by which they are tested and evaluated (Driver, 1983).

All ‘statements’ in Popper’s view of science are impregnated with theories, i.e. no observation can be theory free. He argues that whatever hypothesis comes out of the chaos of ideas, speculations and hunches, must be carefully submitted to the most rigorous evaluation (Willig, 1990). All scientific knowledge is therefore provisional.

Science as a co-operative exercise as opposed to an individual venture is emphasised in the writings of Kuhn. Three terms dominate Kuhn’s discourse: ‘normal science’, ‘revolutionary science’ and ‘paradigm’. A paradigm defines appropriate knowledge, provides the framework for what to research, and how to research it. The concept of the paradigm illustrates the nature of socially constructed knowledge in the sense that knowledge is what a community of practitioners define knowledge to be (Kuhn, 1962). In conducting ‘normal science’, scientists accept the paradigm: they test it for further articulation and specification under more rigorous conditions. Kuhn’s picture of the way science develops can be summarised by the following open-ended scheme: “pre-science - normal science - crisis revolution - new normal science - new crisis” (Chalmers 1978, 1987). Normal science describes scientific activity at times when theories are unchallenged. Scientists accept the paradigm and work on what Kuhn calls ‘puzzle-solving’ activities. Scientific discovery, invariably an accidental process, commences with an awareness of an anomaly (Kuhn 1962). When an anomaly is perceived and

acknowledged, there is a crisis and much insecurity amongst scientists. Scientists do not immediately abandon the paradigm: the decision to abandon the old paradigm is simultaneous with the acceptance of a new paradigm. When a new paradigm is accepted, a revolution has taken place.

A number of problems with this theory have been raised especially as regards the concept of paradigm. However, Kuhn's work was important in that it directed the attention of those interested in the development of knowledge away from the methods and logic of scientific discovery stressed by Popper to the social and conceptual frameworks that guide scientific enquiry.

This review of different views of the nature of science is an effort to place in perspective the responses of teachers to questions about what they expect pupils to be able to do on entry to secondary school, as well as questions about classroom practice. The learning and teaching experience of most teachers lies strongly fixed within a traditional view of the nature of science. It is important to recognise this fact, but also to see that this can no longer be an excuse for what is carried out in the name of 'science'

### **2.3. LEARNING SCIENCE AND SOME THEORIES OF COGNITIVE DEVELOPMENT**

Driver (1983) presents the view that scientific theories are not deduced from data, but are constructions of the human intellect. An important proponent of this view is the

epistemologist Jean Piaget. This discussion will outline some of the features of the Piagetian approach relevant to this research in the classroom, rather than serve as a detailed review of his work.

### **2.3.1. PIAGET'S DEVELOPMENTAL THEORY AND MODEL OF KNOWLEDGE**

Piaget proposed that knowledge is constructed through a person's interaction with the environment. An exploration of the environment is essential for the development of new ways of thinking. According to Medler (1992), Piaget's theory is supported by 3 major assumptions:

- Knowledge is not an objective entity in the environment: it is the interaction between the individual and the environment.
- Growth of intelligence, like biological development, is dependent on the construction of new structures from prior structures.
- The factors that influence cognitive development are the physical environment, the social environment, maturation and the individual self-regulation processes (all essential for cognitive growth).

Cognitive development according to Piaget (1977, p.3) is effected by 3 basic processes: assimilation, accommodation and equilibration. Medler (1992) briefly summarises each as follows. Assimilation is the integration of new data with existing cognitive structures. Accommodation is the adjustment of cognitive structures to a new

situation, and equilibration is the continuing readjustment between assimilation and accommodation.

Cognitive conflict arises between people's expectations and observations when they actively interact with their environments. Piaget felt that the intrinsic motivation for learning came from a need to resolve this conflict. Such a view of learning as equilibration places the learner in an active role.

There is a need to focus somewhat on Piaget's stage theory as a framework for the research project of the Assessment of Performance Unit (APU) in the United Kingdom. Some of the questions developed by the APU, for assessment of 11 year old British children, were used in this research. The APU focused on assessment of students at the ages of 11, 13 and 15 years. It was felt that by the age of 11 children could have developed skills, attitudes and concepts more specifically related to science activities (APU 1984).

Joan Bliss, who worked with Piaget for nearly a decade, states that Piaget was one of the first to put forward forcefully, with supporting evidence, the notion that children construct their own knowledge and that this knowledge is different in kind from an adult's, evolving and changing over years. Piaget postulated a series of qualitatively different stages to describe children's intellectual development from birth to adolescence (Bliss 1995, p.141). The stages are widely regarded as universal and predictable. Four broad periods or stages of cognitive development were identified in Piaget's early investigations of children's thinking.

Table 2. Summary of Piaget's four broad stages of development. (Adapted from Medler 1992, p. 230).

STAGE	OVERVIEW
Sensori-motor (birth to 1-2 years)	Presymbolic and preverbal. Intelligence involves the development of action schemes.
Pre-operational Period (2-3 to 7-8 years)	Partially logical thought begins. Language development begins - spontaneous speech mainly monologue.
Concrete operational (7-8 to 12 -14 years)	Rudimentary reflection. Logical ways of thinking linked to concrete objects. Thought to be independent of perceptual cues.
Formal operational (older than 14 years)	Capable of dealing logically with multifactor situations. Can reason from the hypothetical situation to the concrete.

Although individuals move from one stage to another at different ages, the stages occur in a sequential order, i.e. each stage in cognitive development is necessary for the following to occur. These stages are not always viewed as being separated by precise boundaries that an individual has to cross. Piaget himself has stated that individuals may display formal operations in an area familiar to themselves, while functioning concretely, at least initially, in unfamiliar fields. This is supported by Nickerson, Perkins and Smith (1985) and Driver (1983) who state that the ability of a pupil to use a certain logical operation depends on his familiarity with the context within which a task is set. However, according to Piagetian theory, "neither previous experience, the social context, nor individual interests are thought to override the primacy of the child's cognitive stage in determining what can be learned, and should be taught, within a narrow age range" (Howe 1996, p.45).

Educators mostly used stage theory as a tool to match the content of science curricula to children's spontaneous intellectual development. This is used to decide which science concepts are appropriate for students at the various grade levels. In the mid-1970's Shayer, Kucheman and Wylam (1976) and Shayer and Wylam (1978) carried out a large scale survey of pupils' thinking between the ages of 11 and 16, to document their intellectual development according to Piaget's stages (Bliss 1995, p.43). They found that only 20% of children in England's comprehensive schools were in Piaget's formal operational stage at the age of 16. The context effect (different learning situations for pupils) on performance, however, calls into question the usefulness of applying a 'matching model' to prescribe the teaching materials which are appropriate to the learners stage of development.

Bliss (1995) raises the issue of some challenges to Piaget that are particularly relevant to science education. Firstly, there are the queries about the appropriateness of the description of "formal operations". Even before Shayer's study mentioned above, educators in the classroom argued that most secondary school pupils did not operate within the formal operational stage as described by Piaget. There is also the realisation of the importance of the socio-cultural context of learning i.e. the "situatedness" of learning. Context and cultural practices are now seen as the fundamental units within which cognition has to be analysed. One of the basic assumptions is that action is mediated and cannot be separated from the milieu in which it is carried out, the mediational means being tools and language.

Piaget described logical thinking and reasoning about complex situations as the highest form of cognitive development. He grounded his investigations in the individual child's manipulation of and interaction with objects in his or her particular environment. A shift in focus from the child as a solitary thinker to the child in a social context has tended to provide an impetus for change once again.

### **2.3.2. A VYGOTSKIAN FRAMEWORK**

Vygotsky, in contrast to Piaget, grounded his analysis in the cultural history of the human race and the child's interaction with others in his or her particular culture. A basic premise of Vygotsky's theory is that the signs and symbols of a culture, and particularly language, are the key to understanding complex human behaviours.

The main tenets of his theory may be formulated as follows (Davydov and Zinchenko 1987, p.29) quoted in McDonald (1993).

- The basis of man's mental development is a qualitative change in his social situation (or his activity).
- Learning and upbringing are universal aspects of human mental development.

The origin of activity is its expanded performance by a person on an external (social) level. New mental structures forming in man derive from internalisation of the initial form of his activity.

Vygotsky maintains that diversity in symbols leads to differences in the level of mental functions that are developed. Therefore universal stages of psychological development across cultures cannot be identified (Medler 1992, p.268). He distinguished between the



concepts formed from a child's experience and independent thinking (everyday concepts) and those concepts learned in school (scientific concepts). He saw a dialectical relationship between the two types of concepts. According to Ann Howe (1996), conceptual change is an ongoing process in which the child, in collaboration with a teacher or other student, integrates everyday concepts into a system of related concepts and transforms the raw material of experience into a coherent system of concepts. The emergence of a conscious awareness of mental processes is important. The child reflects on what she has learned in school, and by reflection, raises to the level of consciousness what had previously been non-conscious (Howe 1996, p.39). The key to the development of complex mental functions is mastering the signs and symbols of the culture and learning to use them to direct and regulate one's own behaviour.

One of Vygotsky's most powerful ideas is related to the 'zone of proximal development'. This zone is defined as the distance between the actual developmental level that is reflected in the child's independent problem-solving, and the problem-solving level that can be accomplished with guidance (Vygotsky 1978 p86). Stated differently then, it means that at any given stage of development a child can only solve certain problems ~~under the~~ guidance of adults, or in collaboration with more able peers, but not independently. At the next stage of development the child will be able to solve those problems independently.

The implications for science instruction within a Vygotskian framework need some attention. Many of these are raised by Howe (1996).

- a) There must be a move away from the individual constructing meaning to an emphasis on knowledge originating in social interaction.
- b) Language is a vital tool to support and promote thinking. Language is used as a means to stimulate pupils to reflect and explain in order to understand how their experiences and their context-bound knowledge fits into a larger system. Children would be allowed to use their own language as a tool for thought and communication as they gradually learned to use the special language of science.
- c) Curriculum and instructional practice must take cognisance of the context in which science concepts are embedded. Context, rather than cognitive demand, of the task is the important consideration in making instructional decisions.
- d) Considering the principle of the zone of proximal development, learning should be constructed collaboratively. Learning should be structured in such a way that the teacher completes difficult aspects of the task until the child is able to master them. As the child gains proficiency, task demands are raised until the child is functioning independently and the teacher functions as a supportive observer (Medler 1991, p.297).

The Vygotskian view of development also has implications for the area of conceptual change and children's misconceptions about scientific phenomena. The work of Driver, Guesne and Tiberghien (1985) gives accounts of children's ideas. It is their contention that students approach experiences presented in science classes with previously acquired notions and these influence what is learnt from new experiences in a number of ways. "What children are capable of learning depends, at least in part, on what they have in their heads as well as on the learning context in which they find themselves" (Driver,

Guesne and Tiberghien 1985, p.4). It is thus assumed that each child comes to school with misconceptions or alternative frameworks about natural phenomena. Examples of the sorts of principles and phenomena that have been studied are gravity (Gunstone and White 1981), heat and temperature (Erickson 1979) and light (Anderson and Karrquist 1983). Generally, misconceptions are seen as those student's ideas which are incompatible with currently accepted scientific knowledge, and which even though they do represent creative constructions by the individual, have been found to present significant difficulties in learning (Clement, Brown and Zietsman 1989, p.555). These misconceptions are then challenged by providing new information that will induce cognitive conflict. This conflict, it is hoped, will lead the child to recognise inconsistencies and then reconcile them through accepting a more logical and general concept. Alternative conceptions are not abandoned simply by listening to a teacher or observing an experiment. Fundamental conceptual change involves a recognition of existing belief, a reconsideration and weighing of its value and accuracy against the new information, and a decision to restructure the belief (White and Gunstone 1989, p.578).

Although this model has been useful and productive its continued usefulness has been questioned by Pintrich, Marx and Boyle (1993) who point to what they see as deficiencies, including its lack of contextual factors. According to Howe (1996), a Vygotskian view of the development of concepts in science would accept children's ideas as a starting point with a view to helping them expand their knowledge, learn to use it more flexibly, apply it to more situations, and eventually integrate it into a system of broader, more inclusive concepts. This view seems less confrontational in that the ideas

of the child are not directly challenged, but there is rather an emphasis on discourse to establish the foundation on which to build new knowledge.

### **2.3.3. A CONSTRUCTIVIST MODEL**

Earlier views of learning were within a behaviourist or a developmental mode. The behaviourist mode is criticised on the grounds that there is no room for considering individual differences between learners or the idea that differing forms of knowledge can be equally valid. The developmental mode, as described earlier, is prescriptive in the sense that it sets out the order in which increasingly complex cognitive operations become available to the learner (Driver, 1994).

A constructivist model of knowledge is now a pervasive paradigm and has its roots in Piaget's genetic epistemology and the writings of philosophers such as Popper, Kuhn, Lakatos and Toulmin. Constructivism did not originate with Piaget, but his work gave it currency. Driver and Easley (1978) are generally credited for the accelerated rise of constructivism in science education (Solomon 1994, p.3) when they argued that "achievement in science depends to a greater extent upon specific abilities and prior experiences, than general levels of cognitive functioning". Constructivism says that knowledge is constructed: but beyond that it is a many headed beast (Bliss 1995, p.54). In spite of the apparent diversity however, the two central premises of the different constructivist epistemologies are:

- that knowledge is actively constructed by the learner, not passively received from the environment; and

- that knowledge is socially constructed through experience with the physical world and social interaction leading to consensus.

The two most clearly elaborated epistemological positions of constructivism are those of the radical constructivist and the social constructivist (Osborne, 1996). Osborne feels that at the heart of the radical constructivist writings is the desire to escape notions of 'absolute truth'. The radical view is that there is no knowledge without the knower i.e. there is no independent, pre-existing world outside the mind of the learner. The social constructivist perspective portrays science education as a process of enculturation in which "aspirant members of a culture learn from their tutors" (Driver et al. 1994). Knowledge is seen to be primarily fashioned and made by human discourse.

Vygotsky (1978), Driver and Easley (1978) and Driver and Erickson (1983) have all stated that, for meaningful learning to take place, learners must make a deliberate effort to relate new knowledge to relevant concepts they already possess. Constructing links with prior knowledge is an active process and involves formulating, checking and restructuring ideas. The call for recognition of the learner's sociocultural background has been supported by many people, amongst them Driver (1979); Jegede (1995); and Ogunniyi (1988). The social context acts as a scaffolding, providing assistance which fosters the construction of knowledge while the learner interacts with other members of the society.

Jegede (1995) raises some important concerns about learning science in an African multicultural classroom. He feels that constructivism works very well when African

children have to learn about things within their environment using their prior knowledge situated within their non-Western worldview. "Problems arise when they have to now learn Western science and technology in schools and also learn the Western culture along with the subject" (p.18). Both worldviews, since they are not reduced to the level the student can understand and find immediate use for, cannot co-participate in or be used for the construction of knowledge. "Prior knowledge then becomes a handicap because it is situated within the African worldview and it is being used as a framework or antecedents for learning science and technology from a Western perspective" (Jegede 1995, p.18).

This point is important for teachers to understand, especially in the multicultural South African classroom of today. So often remarks are made about second language learner's lack of participation in classroom discussion. The language is often regarded as the only barrier to more effective participation. Here one is alerted to the need for a much deeper consideration of sociocultural background factors that probably clash with the acceptable Western science of the classroom. Driver et al. (1994) assert that "learning science in the classroom involves children entering a new community of discourse, a new culture" (p11). The role of the teacher becomes crucial. When a student's answers deviate from the teacher's expectations, this should provide insight into what the student is thinking, rather than being seen as a wrong answer. The knowledge gained through negotiation of meaning is useful as long as it 'fits' with the learner's experience and gives them a perspective on their environment.

This review of aspects of constructivism has been undertaken mainly to highlight an approach that stresses the importance of learners and the value of the knowledge they bring to the classroom situation. It is also relevant to the present research which recognises the complexity of creating an effective learning environment for children who bring with them very different primary school experiences.

#### **2.4. LANGUAGE AND SCIENCE EDUCATION**

Science education in a multilingual situation demands some consideration of the issues of language. Language is a cultural artefact. The ways in which we use it for remembering, reasoning, evaluating and communicating are socioculturally determined and have to be learned. “In his development, the child’s first social relations and his exposure to a linguistic system ..... define the forms of his mental ability” (Luria 1976, p.9).

In the context of multicultural science education, there are several aspects of what is commonly referred to as the ‘language problem’. Hodson (1993) identifies these as:

- the diversity of mother tongue;
- the language of science which is characterised by specialised terminology, use of everyday words in specific, restricted contexts and the style of written communication;
- the stylised language of classroom interaction;
- the use of language-based activities to bring about learning (p.11).

The research reported in this dissertation was conducted using a standard 6 pupil population comprising both English first and second language learners whose medium of science instruction is English. The feeder schools from which the second language learners have come have been historically sub-divided along ethno-linguistic lines. The medium of instruction for the first 4 years of schooling has been in the language of the school, in this case mostly Zulu. In the fifth year of schooling the language of instruction changes to English. Hence most black South African children learn their formal school subjects in English which is a second language for them. According to Sentson (1994), at the time that black South African pupils are expected to convert to English as a medium of instruction, they have spent less than 9% of the amount of time learning English at school compared to the time spent by pupils learning English as a first language (p.110). These pupils are then expected to learn in English, regardless of the disadvantages they are faced with. "The issue of language again complicates the matter of learning and teaching science in Africa where the subject, the culture of the subject, the language of instructing the subject and the language of discourse are all unfamiliar to the learner" (Jegede 1995, p.20)

The aim here is not to review second language teaching *per se*, but rather to examine the 'language position' in which the pupil finds her/himself in the present South African multilingual classroom, especially in relation to science education. The research evidence will draw attention to the fact that the second language learner is at a disadvantage in a traditional science classroom that does not take heed of his/her language background.



Learning in a second language has been shown by several authors (see list in Sentson 1994) to create a situation in which the assimilation of knowledge is severely impaired. Researchers have also identified problems of learning mathematics and science in a second language. In the South African context, McNaught (1994) suggests that there are considerable problems around constructing meaning at the interface between Zulu and English. Rutherford and Nkopodi (1990) however, found that recognition of basic science concept words was better in English than in the vernacular. Tobin and McRobbie (1996), in their investigation of Chinese-Australian chemistry students, found that difficulties in speaking and writing English were factors that limited performance (p.265). "Those Chinese students who succeeded in passing chemistry did so because they were able to learn English relatively quickly and overcome barriers of having limited proficiency in English in a system that is built on a hegemony of learning and being assessed in English" (Tobin and McRobbie 1996, p.280).

Brodie (1989), Dawe (1983) and Austin and Howson (1979) are some of the researchers who have confirmed that a relationship exists between language and thought, based on the writings of Piaget, Bruner and Vygotsky. The Sapir-Whorf hypothesis asserts that languages, in some ways, shape the way we think. Sapir (in Brodie 1989, p.43) claims that "we see and hear and otherwise experience very largely as we do because the language habits of our community predispose certain choices of interpretation." Mori, Koyima and Tadang (1976), in their work with Thai and Japanese-speaking children's use of words which connote speed concluded that language has a significant effect on conceptual interpretation, and, therefore, on the learning of science (Baker and Taylor 1995, p.696). Mori et al. argue that the words themselves are not as important to

learning as are their culturally applied connotations. Bamgbose (1984) and Collison (1974) have both shown, in their separate studies, that scientific concepts are best learned in the student's mother tongue, in spite of technical limitations of that language. Another point to consider is the fact that... "encouragement to develop L1 skills is necessary if the child is to develop competence in L2 and if the child receives instruction in a foreign language without simultaneous support in her mother tongue, both languages as well as the child's cognitive development and school achievement will suffer" (Brodie 1989 , p.45). Baker and Taylor (1995, p.697) conclude that the personal construction of meaning in science is related to the linguistic background of the learner, and to the compatibility of the learner's language with that of science education.

David Brookes (1995) stresses the importance of language and differentiates between ordinary language and scientific language as shown in Table 3 below. Brookes states that if we use ordinary language for scientific knowledge it causes confusion. On the other hand, immediate use of scientific language for scientific knowledge is also a barrier to meaningful learning. The change from ordinary language to scientific English occurs gradually as ideas are exchanged to give scientific knowledge.

Table 3. Differentiation between ordinary language and scientific language (adapted from Brookes, 1995).

<b>ORDINARY LANGUAGE</b>	<b>SCIENTIFIC LANGUAGE</b>
1. everyday experience	used for scientific knowledge
2. context dependent	less dependent on context
3. less precise	more precise
4. personal background and knowledge	high level of social construction

Rampal (1994, in Jegede 1995, p.19) commenting on the situation in India, says that many students never make it to high school because an emphasis on rote memorisation of remote science concepts in a formidable foreign language alienates the majority of young children, and they drop out long before they complete elementary school. This is very likely to be the case in the South African school situation as well.

Classroom experience shows that pupils often have to mentally translate the science and mathematics learned in English into their mother tongue for meaningful understanding to result. This 'translation' however poses its own set of problems for the learner, since often there can be no direct translation of words from one language and culture to another. "The more the cultures are different, the more the thoughts conveyed by the words are different, and the more difficult the translation" (McKinley, McPherson, Waiti and Bell 1992, p.590). In 1968, Case, reporting from Malawi, isolated several factors where difficulties may be experienced in the 2-way communication between teacher and pupil, all of these caused by second language problems. These were listed as (Kotecha, Rutherford and Starfield 1990, p.215):

- direct translation, particularly where English did not have a 1-1 relationship to words in the vernacular;
- pronunciation;
- 'deficient' vocabulary;
- prepositions and articles;
- subjects;

- problem words, usually familiar words which create trouble when used in a scientific context.

Rutherford and Nkopodi (1990) have commented on the inability of some traditional languages to support the analytical and logical thought used in western science, as such things as logico-grammatical connectors or articles do not exist. Discourse patterns also differ across languages and cultures. Some students, for whom English is a new language, may have an understanding of science concepts, but lack the vocabulary to convey their understanding. Others may understand the concepts, but use discourse patterns incompatible with the ways in which science content is discussed in English (Lee, Fradd and Sutman 1995, p.799). Still others have both the concepts and the discourse patterns but lack the social pragmatic knowledge of how to participate in class activities and display their understanding in classroom contexts (Tharp and Gallimore, 1988).

Lee et al. (1995) feel that this raises important issues about science instruction. Students who are not able to apply precise science vocabulary, and who express their ideas in indirect and unclear terms, can give the impression that they do not have the knowledge when in fact the knowledge is present. On the other hand students who possess the vocabulary might be perceived to have science knowledge even though they do not understand the meaning of the terms (p.809). Cummins (1981) advises us that conversational English should not be used as a guide for predicting success in the classroom. He feels that the kinds of language skills needed to learn academic subject matter and carry out demanding assignments are much more complex than those used in everyday conversation. Cummins hypothesizes that there exist two types of language

proficiencies which can be classified as follows (Cummins, 1980; Cummins and Swain, 1986 summarised in Rosenthal 1996, p.46-47):

- **BICS** - this stands for Basic Interpersonal Communicative Skills and refers to everyday conversational ability that is 'context embedded'. Facial expressions, hand gestures and the tone of the speaker's voice may contribute to the negotiation of meaning by the participants in the conversation.
- **CALP** - this stands for cognitive/academic proficiency, particularly in the academic setting, where language is 'context-reduced'. Events or topics are usually unfamiliar to the listener, with little or no opportunity to negotiate shared meaning. Compared to BICS, CALP requires much higher order language and cognitive skills.

The language used for assessment is also important, particularly in this research. Michell (1992, in Doran et al. 1994) noted that "Evaluation sends a message. It points to what is valued and ignores what is perceived to be unimportant" (p395). Thus to ignore the language of assessment for the second language learners would be to assume that it will not significantly affect assessment of skills. "When a bilingual individual confronts a monolingual test, developed by monolingual individuals, and standardised and normed on a monolingual population, both the test taker and the test are asked to do something that they cannot. The bilingual test taker cannot perform like a monolingual. The monolingual test cannot 'measure in the other language' " (Guadelupe and Figuerose 1994, p.87). In South Africa, Cecilia Sentson (1994) looked at the effect of language of presentation on pupil's performance in a mathematics test. Two mathematics tests, one in South Sotho and one in English, were administered to standard 10 pupils at a predominantly black South African secondary school. All pupils selected for the test had

South Sotho as a first language. Her findings suggested that “the process of learning mathematics in a second language is affected not only by factors pertaining to the effective use of language, but also by issues of culture of both the learner as well as the teacher, as well as methods of logic and reasoning” (p113).

#### **2.4.1. Implications for classroom practice.**

The study by Lee et al. (1995) used four culturally and linguistically diverse groups of elementary students to look at science knowledge and cognitive strategy. The findings indicated distinct patterns of science knowledge among the four ethnolinguistic groups, as well as distinct patterns of strategy use (p.809). Several possible explanations for the differences were put forward. Summarised these relate to the following.

1. Students’ personal experiences and prior knowledge as related to science tasks.
2. The language background that students brought to the setting.
3. The teachers’ ability and performance in eliciting, probing and prompting.

By definition, both (1) and (2) reside within the standard 6 pupil population on arrival at high school so that the key to meaningful learning in this situation lies with the teacher. Many approaches to educating minority language students seem to be based on the assumption that English is a pre-requisite for academic learning. This is prevalent even though some research seems to indicate that it may take as long as seven years for students to acquire a level of academic English proficiency comparable to native English-speaking peers (Cummins, 1980). This assumption is evident in programmes within the research school, where increased English proficiency is thought to be the key to improved academic results. Clearly, the teachers’ role (and not English proficiency alone) is central in ensuring that students acquire the skills and knowledge in the school’s

curriculum at a similar level to those students who are learning it in their native language. The role of the science teacher within the multicultural science classroom must move away from the transmission of facts: "...teachers must be skilled in negotiating meaning; they must have well developed skills in monitoring student performance; they must be expert in instructional decision-making; they must serve as a role model for use of language, cultural behaviours and learning strategies, and they need to structure the environment to facilitate language learning" (Met 1994, p.167).

## **2.5. THE SKILLS APPROACH IN SCIENCE EDUCATION**

It is widely acknowledged that traditional approaches to education have focused on the teaching of factual knowledge, with lip service paid to the development of skills and processes. "The focus of teaching has been on the science content, with the processes being hopefully caught rather than explicitly taught" (Screen 1986, p.16). Syllabi consist of a list of topics to be "covered".

Change within the education system of South Africa has seen a renewed emphasis on skills. The ability to think effectively has always been important, but it seems to have become even more important in recent times. Now it seems urgent that we have the ability to adapt, to learn new skills quickly and apply old knowledge in new ways. A recent report in a national South African newspaper revealed some shocking statistics as regards South African school children. South African standard 5 and 6 pupils came last out of a class of about half a million teenagers worldwide who took the tests in the Third International Mathematics and Science Study. The average South African standard 6

pupil tested answered just 24% of the maths questions and 27% of science questions correctly, compared with world averages of 55% and 56% respectively. The test was designed to assess educational standards and ability to solve problems using learned knowledge combined with common sense (Sunday Times 24-11-96). The same article states that "... South Africa was at the bottom of the class in every category, its teenagers woefully equipped for the demands of a hi-tech global economy".

Most documents, when discussing the new education dispensation, talk about a shift towards skills-based learning e.g. "...the emphasis in the curriculum should be on developing skills such as gathering information, recording and analysing information for the purposes of solving problems, making decisions and social action" (Rollnick and Perold 1995, p.121). Grayson (1995) writes that "we should be helping develop students who are skilful at thinking, reasoning and experimenting, students who can solve problems and grasp concepts, students who reflect on what they do and how they think and learn" (p.57). A point made in the new interim biology syllabus in use in secondary schools states that "while the content has remained largely unchanged, this is regarded as an opportunity for a shift in emphasis from rote learning to a competency-based approach." The guideline document issued to teachers of General Science (biology component) provides information about the General Education Certificate examination to be completed in 1997: "as this is the first external examination of this nature that many pupils will write..... it is important to point out that the examination may be quite different from previous examinations written by the pupils. This examination will focus on the skills and processes outlined in the aims and objectives supplied" (Kwa-Zulu Natal Dept. of Education and Culture 1995). Gordon et al. (1995) further differentiate



between learning outcomes, competencies, skills and concepts and feel that “it is essential that skills and concepts are articulated within the curriculum to ensure that themes and content are not trivialised” (p.15).

This renewed commitment to development of skills is shrouded in a terminology which seems to mean different things, especially to teachers in the classroom, with terms often used interchangeably without clear definition. According to Muller (Biology INSET 1995) skills and processes refer to what pupils do and how they learn. Gordon et al. (1995) feel that concepts include the key issues in the curriculum, embracing content, understanding and an ability to apply in practice. Skills they feel, include higher order cognitive skills and processes (like problem-solving processes or making and testing hypotheses) (p.15). Grayson (1995) feels that teaching for understanding (as opposed to teaching knowledge only) requires explicit development of the following skills: practical skills, thinking skills, reasoning skills, problem-solving skills, conceptual understanding and reflection skills or metacognition (p.55). The distinction between thinking and reasoning skills is blurred and some people clump them together using the term ‘cognitive skills’.

Screen (1986) defines processes as “the sequence of events which are engaged when researchers take part in scientific investigation ... they seem to build into a hierarchy, at least initially, though once entered into the whole becomes cyclical” (p.14). Donnelly and Gott (1985) offer a working definition of ‘science processes’ as “classes of tasks undertaken by pupils and which can be

- identified across a wide range of disciplinary areas; and

- systematically connected with a specifically scientific epistemology (taken to be analytical, manipulative and materialist)” (p.239).

This approach is seen to impose limitations on the idea of generalized science processes in the face of complex phenomena.

The process and skills movement gained prominence in about 1967 through a scheme developed in America called ‘Science - A Process Approach (SAPA). SAPA placed a firm emphasis on scientific method or ‘process.’ A set of abstract process headings were established at two levels. According to Donnelly and Gott (1985), these were called basic processes (observing, classify, inferring, etc.) and integrated processes (formulating hypotheses, interpreting data, etc.) respectively (p.237). This type of programme gives extensive practice in component cognitive operations in the belief that more complex activities result from this practice.

Hence, in the process and skills movement, ‘processes’ were intended to refer not to the practical skills associated with science, but to the cognitive processes such as observing, classifying and inferring, i.e. the thoughts that go through scientists’ minds as they perform practical science activities (Gott and Duggan 1995, p.19). The Warwick Process Science Project had as its objective to produce a ‘process-led’ curriculum in contrast to the ‘knowledge-led’ curriculum most pupils follow (Screen 1986, p.12). Screen goes on to state that the processes that feature in this project are those that build up an intellectual framework for problem solving; more explicitly, observing, referring, classifying, predicting, controlling variables and hypothesising (p.14). He was of the opinion that these processes need to be taught overtly, and in the first instance in the context of

science, but without the encumbrance of having to assimilate a body of facts at the same time. It was, however, felt that the term 'process - skills' which was widely used at the time was a contradiction in terms, confusing the cognitive processes element with the practical skills element, leading to a lack of clarity of definition. In general, schemes that adopt the process approach aim to consider, as far as possible, one process at a time as the focus of a lesson.

After the process and skills movement, came the move towards the holistic approach referred to by Woolnough (1991) in the form of scientific investigations. Investigations aim to allow pupils to use and apply both concepts and cognitive processes, as well as practical skills (Gott and Duggan 1995, p.20). This move was driven by the Assessment of Performance Unit's (APU) work in science. A brief explanation of the aims and types of assessment surveys carried out by the APU will be provided mainly because the assessment in this research used some of the questions designed by this unit.

### **2.5.1. THE ASSESSMENT OF PERFORMANCE UNIT**

The Assessment of Performance Unit (APU) was set up by the Department of Education and Science (DES) in the United Kingdom, following political debates in the 1970's which expressed concern about standards in education. The APU was to promote the development of methods of assessing and monitoring the achievement of children in school, and to identify the incidence of underachievement. According to Raper and Stringer (1987), the view of primary science which the surveys attempt to reflect is that:

- it is a rational way of finding out about the world, involving the development of a willingness and ability to seek and use evidence;
- it involves the gradual building of a framework of concepts which help make sense of experience;
- it fosters the skills and attitudes necessary for investigation and experimentation (p.7).

Process skills, attitudes and concepts of science are seen to interact, both in learning and in applying them. Almost a quarter of a million individual students from primary, middle and independent schools in England, Wales and Northern Ireland were tested with some of the APU instruments, with data gathered annually from 1980 to 1984. These extended tests, in which several papers were produced and given to different, but parallel samples of pupils, provided the opportunity for a wide ranging review of what constituted science in schools at that time. The focus of the assessment was on students at ages 11, 13 and 15 years. The 1982 survey involved a sample of 870 schools in England, Wales and Northern Ireland. 12 573 pupils were given one of 16 different written tests and a sub-sample of 1990 pupils was given individually administered practical tests.

Scientific performance is too complex to be adequately represented by a single overall score. Hence, it was necessary to break down the 'scientific performance' into different parts which had meaning both separately and in combination (Harlen, Black and Johnson 1981, p.12). "The aim of the assessment is to see how well children can use the process skills of science and apply ideas in solving problems through investigation" (APU, 1984). After much consultation, negotiation and compromise the assessment was based on a framework comprising six science activity categories. The framework for assessment

allows for testing of separate process skills and for testing of performance in carrying out investigations. The framework categories and subcategories of performance which are assessed by APU are given in table 4 below.

Table 4: Categories and sub-categories of science performance assessed by APU (APU, 1984).

NO.	CATEGORY	SUB-CATEGORY
1.	SYMBOLIC REPRESENTATION	Reading information from graphs, tables or charts. Representing information as graphs tables and charts.
2.	USE OF APPARATUS AND MEASURING INSTRUMENTS.	
3.	OBSERVATION	Making and interpreting observations
4.	INTERPRETATION AND APPLICATION	Interpreting presented information. Distinguishing degrees of inference. Applying science concepts to make sense of new information. Generating alternative concepts.
5.	PLANNING INVESTIGATIONS	Planning parts of and /or entire investigations. Identifying or proposing testable statements.
6.	PERFORMANCE OF INVESTIGATIONS	

Practical tests were used to give information about the children's:

- a) ability to perform investigations;
- b) skill in observing;
- c) ability to used simple measuring instruments and equipment; and
- d) reactions to science-based activities.

Written tests were used to test the children's ability to :

- a) plan investigations;

- b) interpret and explain information given in the question by making use of patterns in the data or suggesting hypotheses; and
- c) use graphs, tables and charts (Raper and Stringer 1987, p.7).

It was considered more useful to report performance on groups of questions which relate to specific abilities within each category, since these have more meaning than the more general category headings (Harlen et al.1981, p.10). Performance on the sub-categories often forms the main basis for reporting results. The more detailed results from the APU surveys will be discussed in relation to the findings of this research.

### **2.5.2. SOUTH AFRICAN SITUATION**

In the South African context very little work has been done in the area of science assessment at the primary school/secondary school interface. A detailed study using a science process skills test for standard three (grade 5) General Science, was carried out by McDonald (1990) in her work on the Threshold Project. Harlen (1985) set out a list of process skills thought to be achievable by British school children by the fifth year of primary school. McDonald modified the list, taking account of the level of language skills developed in black South African pupils by their fifth year of schooling. She put forward the following list of process skills she saw as feasible by the fifth year of schooling:

#### **A. Observation**

1. Using the senses to gather information.
2. Identifying differences between similar objects/events.

3. Identifying similarities between different objects/events.
4. Recognising the order in which sequenced events take place.

### **B. Interpretation of information**

1. Identifying trends or patterns of information.
2. Understanding patterns or relations in recorded data.
3. Using patterns or relations in information, measurements or observations to make predictions.

### **C. Inference**

1. Putting together information and making deductions.
2. Suggesting relations to account for the existence of patterns.
3. Realising that checking an inference requires more information of a different kind.

### **D. Explanation**

1. Attempting to explain observations or relations in terms of some principle or concept.
2. Realising that there is some similarity between two situations and applying concepts or knowledge gained in one situation to help understand or solve a problem in another.

### **E. Devising Investigations**

1. Deciding what equipment, materials etc are needed for an investigation.
2. Identifying what is to change or to be changed when different observations or measurements are made.
3. Identifying what variables are to be kept the same for a fair test (p.33).

McDonald states that “we were pleasantly surprised by how much the children were able to give us in this process skills test” (p.34).

Two of the points highlighted by her work bear relevance for the interpretation of the findings of the present research. The first is that although pupils appeared to exercise process skills appropriate to the section used for testing, they (the researchers) could not thereby conclude that the children would be able to deal with the concepts and skills intrinsic to the rest of the syllabus. It is accepted that process skills are not exclusive to science, nor do they constitute science, but they are a necessary part of science.

Secondly, there was the finding that the children were able to deal better with higher order concepts orally rather than in the written form, in the mother tongue ( McDonald 1990, p.35). This research used written tests for assessment and thus the reader must bear in mind the statements of McDonald in the final analysis.



## **CHAPTER THREE**

### **RESEARCH METHODOLOGY**

#### **INTRODUCTION**

A glance through the literature indicates that research in education has been classified from many different points of view: according to the discipline (e.g. psychological, sociological etc.); according to the type of data collection procedures (e.g. interviews, testing etc.) or according to the methods employed (i.e. historical, descriptive and experimental) (Verma and Beard 1981, p.35). A simple dichotomy frequently used in educational research is that between quantitative and qualitative. It is important that these labels are not taken to represent discrete groupings, because sometimes a piece of research may fall into more than one of these categories. This is the case with the research reported here.

The aim, as already explained, was to assess the performance of the standard 6 pupils in certain science areas (skills and content) on entry to secondary school. The intention however, was not simply to provide a report of summative academic performance for this particular group of pupils. A strong emphasis on numbers of pupils passed or failed, without consideration of conditions of present and past schooling experiences, would then allow the research to fall into the 'trap' of the traditional empirical-analytical model of research, developed within a culture of positivism. "Because of the 'conventional wisdom' nature of this (traditional) research paradigm, much is taken for granted and underlying assumptions about research are seldom questioned" (Urban Foundation 1991,

p.2). From the outset it was felt that the complexity of the continually changing contexts of the education system must be recognised. The student population assessed at the research school could not be viewed as a single homogeneous unit.

The research also aimed to find out the views of teachers and their plans for dealing with changes in the classroom situation as regards skills-based assessment. This methodology (group discussion) fits more with an interpretative approach, where interpretations of situations are important. Curriculum development within an interpretative paradigm serves to bring to consciousness the assumptions and values which are taken for granted in everyday teaching practice. The emphasis is on the process of learning which must be meaningful to the learner.

One of the criticisms of this approach is that “within this paradigm researchers still attempt to remain removed and untainted, thereby missing opportunities and decisions that could enable productive growth. Descriptions are often made without any form of critical or engaged interaction taking place” (Urban Foundation 1991, p.3). However, in this research, the researcher was also the practitioner, involved with both teachers and students on a daily basis. This allowed for more formal aspects of the research but also incorporated much informal interaction with students and teachers within the classroom context. This has allowed a more qualitative research approach and analysis of interpersonal structures. The science department staff at the school realised that some action needed to be taken as regards skills development. The research was to serve as a starting point and hopefully give some direction to a course of action. In this sense

theory and reflection would hopefully feed into the formulation of new practice. The procedures carried out in this research can be listed as follows:

1. Skills assessment by means of a written (English ) test taken by all standard 6 pupils. The same test, having been translated into Zulu, was then written by the second language pupils, with pupils answering in their mother-tongue.
2. Content assessment test (English only) taken by all standard 6 pupils. Only the results of the three classes taught by the researcher were analysed for this section of the research.
3. Questionnaire sent to standard 5 teachers in the feeder primary schools.
4. Questionnaire administered to science teachers in the research school.
5. Group discussion with science teachers in the research school.

### **3.1. RESEARCH SETTING**

This research was carried out at an urban secondary school in KwaZulu-Natal. The school caters for pupils from standard 6 (grade 8) to standard 10 (grade 12). Until 1994, the school was under the administration of the ex-House of Representatives. At the time of this investigation, the school was administered by the KwaZulu Natal Department of Education and Culture and has 1200 pupils. The medium of instruction in the school is English. Almost half the pupils of the student population have Zulu as a first language and English as their second language. Science teaching facilities and personnel available were described in Chapter one.

### **3.2. ASSESSMENT OF SCIENCE PERFORMANCE: SKILLS TEST**

#### **3.2.1. RESEARCH POPULATION**

The assessment was carried out on standard 6 pupils at the research school. These pupils are arranged in class groups from standard 6A to standard 6J. The letters A to J do not indicate academic streaming categories, but the classes were initially grouped according to performance on a written English essay task. Pupils who enrolled at the school after the first school day of the year were placed in classes where space was still available. Most classes consist of a mixture of first and second language learners. Almost 60% of the standard 6 pupil population consists of English second language learners and hence sheer numbers dictate that some classes consist only of second language pupils. The standard 6 pupils receive 5 periods of general science instruction per seven - day timetable cycle. There are three standard 6 general science teachers.

#### **3.2.2. SAMPLE SIZE AND SAMPLING PROCEDURE**

The tests were administered to all 302 standard 6 pupils present at school on the day(s) the tests were written. The researcher decided to use the entire population (rather than a sample) since it was felt that the population was readily identifiable, with sufficient resources to administer the tests. The researcher is a science teacher in the local school defined and access to the pupils could be easily negotiated with other teachers involved. It was also felt that using the entire standard 6 population would allow the researcher to compare the results obtained from various groups e.g. boys/girls, urban/rural. A disadvantage of the choice of entire population assessment was the amount of time taken

for marking and coding of scripts. To ensure some form of uniformity and to get a feel for what type of answers were actually given by pupils, all scripts were marked and checked by the researcher.

### **3.2.3. RESEARCH TECHNIQUE**

The assessment data was gathered by means of a survey. Surveys usually involve the gathering of limited data from a relatively large number of cases at a particular time. This method is frequently employed to indicate prevailing conditions or particular trends. Wiersma (1980) distinguishes between a sample survey and a population survey. Population surveys can be used efficiently with relatively small populations where such studies are feasible, as is the case with the standard 6 population tested. The advantages of survey studies can be summarised as follows (adapted from Verma and Beard 1981).

- An effective way of collecting data from a large number of sources.
- Can usually be carried out fairly economically in a short time.
- Results can often be analysed quickly.
- Surveys provide information for further research.

All the factors listed above were important considerations when deciding how best to assess some of the science skills of the pupil population tested. Verma and Beard also cite one of the limitations of this method as being that the researcher's role is a minor one since contact is seldom made with people who provide the data. As explained in the introduction, this was not the case in this research.

### 3.2.3.1. Written tests

The written tests were compiled using questions adapted from the work of the Assessment of Performance Unit (APU) in the United Kingdom. The surveys of the APU were discussed briefly in the literature review.

#### 3.2.3.1.1. Why the use of APU questions?

a) As mentioned earlier, pupils in the standard 6 classes came from over 100 different feeder primary schools. It can thus safely be concluded that the formal science experience (including content covered) differs for pupils coming from the various schools. Setting a test based on the general standard 5 syllabus might disadvantage pupils from schools where the work was not covered in detail, or not covered at all. Hence there was a need for a more general approach to the testing of science skills. The APU questions satisfied this need. "At pre-secondary stages of schooling science education does not necessarily take place in science lessons or indeed through activities which bear a 'science' label. Reflecting this, many of the test questions do not at all announce themselves as being based on science; they test science process skills in everyday activities" (APU 1984, p.2). Some process skills are, however, more general than others and some are more specifically scientific. In the assessment framework used by the APU, a distinction is made between test questions which only involve everyday knowledge and questions using concepts likely to be encountered in science activities.

b) Each question used in the tests of the APU has already undergone several trials and validation. According to the APU "every question undergoes 4 vetting procedures

(shredding, small-scale trials, large trial scales and validation) during any of which it can be rejected as unsuitable. If considered suitable, however, a number of descriptive labels are attached to the question and then it is incorporated into the appropriate sub-category pool" (APU 1984, p.220). This saved the researcher having to run new sets of trials and validation.

c) The APU tests were designed for pupil performance at ages 11, 13, and 15 and questions were thus graded accordingly. The questions for the test in this research were chosen from the age 11 group. This decision was taken because the tests were originally designed for British pupils whose English language and science development at that age is taken to be more developed than their black South African counterparts who, although on average older on entry to secondary school, have experienced little or no formal science instruction and may have more limited proficiency in English.

d) Within the APU, a great deal of attention was given to producing questions that keep the reading demand to a minimum, both in number and complexity of words used. Each question is presented with the aid of a drawing. The most common form of question requires a short answer to be supplied by the pupil. This attention to language detail was particularly helpful in this research which used a pupil population with varying English proficiencies. Minimum instructions were needed for pupils because of the clarity of the short text and helpful diagrams which served to make the text almost self-explanatory.

### 3.2.3.1.2. Choice of questions for the test

A single test, comprising twelve questions, was compiled by the researcher. The choice of these twelve questions was affected by a number of factors which could be summarised as follows.

1. Time limit imposed by length of school period.
2. Range of skills to be tested.
3. Ease of understanding by pupils.
4. Skills frequently used in standard 6.

Each of these factors will be further discussed below.

The time available for each written test was restricted to a single general science period. This was the amount of time negotiated with the teachers involved. The average time per period is 45 minutes. The researcher also had to allow for the fact that the test would be using material outside the 'content' the pupils were currently dealing with and this might also have influenced the time taken for answering of questions.

The researcher decided to try to assess the pupils' performance over all skill categories used by the APU, rather than investigate a single category of skills. The idea behind this choice was to try to establish whether certain skill areas were better developed than others at this stage.

Since the questions were set originally for British pupils, questions that were used had to be more or less familiar in the South African context as well. The questions had to be



easily understood by the pupils, in order to ensure that it was not confusion of context or setting in the question that led to poor performance. The assessment was primarily of the skills involved and all other misleading factors (context, language, sentence construction etc.) had to be kept to a minimum.

Many questions used currently in standard 6, and especially in standard 7 tests and worksheets, make use of some form of symbolic representation and application of science concepts. Hence two thirds of the questions in the test used in this research cover these areas, as it was generally accepted that pupils would (or should) have achieved some proficiency in these specified areas during primary school. It was hypothesised that pupils would most probably not have received much experience in the other two categories tested i.e. interpreting of presented information and planning of investigations. This was based on the fact, as stated elsewhere in this document, that much of science teaching in our schools still focuses on transmission of facts via subject content. However these (interpreting of presented information and planning of investigations ) are skill areas that need to be developed and hence it was decided to assess the pupils' ability, at this stage, to deal with these kinds of questions.

A criticism that could be levelled at this point is the fact that the number of questions used (12) is small. When a fairly large random selection of questions is taken from an even larger bank, unknown influences (e.g. subject matter, words used etc.) tend to cancel each other out. This will not however happen across the small number of questions used here. Hence results cannot be generalised to all situations, but will pertain only to the performance of this population in their specific context. The choice of

questions that are 'outside' the normal content students are busy with at the time of testing also has constraining implications. As the APU (1980) states "...the result will not be able to reflect accurately what children will be able to do, or how they react, in tackling their normal work" (p2).

#### 3.2.3.1.3. Translation of questions

It has to be acknowledged that a child's performance in written questions has some dependence on reading and writing skills. Since nearly two thirds of the pupils in standard 6 are English second language learners it was decided to try to eliminate the language bias by making the same test available in Zulu. In this way the researcher could also determine to what extent the language was affecting performance in science in those areas tested. The translation of the questions into Zulu was carried out by standard 10 Zulu-speaking biology pupils at the school. As mentioned previously, the reading demand of questions was purposefully kept to a minimum with a diagram to aid each question. This helped to keep the translations into Zulu fairly straightforward, especially since the questions rarely made use of technical science terms that could confuse translations. A cross-check was carried out by a teacher who was proficient in Zulu.

#### 3.2.3.1.4. Administration of tests

The tests were written in mid-February, 1996. In a brief discussion with pupils beforehand the researcher emphasised that teachers needed to plan their work very carefully and for this they relied very much on knowing just what their pupils had learnt in primary school science. It was also emphasised that the marks from the test would not be recorded for formal assessment. This helped to remove some anxiety from the test

situation, mainly because the emphasis was placed on helping teachers to plan, rather than a focus on what the individual can or cannot do.

The tests were administered during a normal general science period (45 minutes). In no case was a shortage of time cited as a reason for non-response, and in fact most pupils handed in scripts well within the time limit. The researcher was able to personally administer the test to 5 classes. In the other cases, the test was administered by the science teacher who was fully briefed about the assessment procedure, reasons etc.

The English medium test was completed first. It was taken by all standard 6 pupils present at school on the day of the test. At this stage no discussion of the test or answers took place between teachers and pupils. The next day the Zulu translation of the same test was completed by the second language learners only. Once completed, all test booklets were collected and handed to the researcher.

All questions were given a numerical score. Mark schemes used were consistent with those used for the 1980 APU survey questions (Harlen et al. 1982). Types of answers were also categorised so that frequencies of different responses, both correct and otherwise, could be reported. All scripts were marked and coded by the researcher. The Zulu answers were translated back into English by the standard 10 and some standard 8 science students. Once again translations back into English were checked by a teacher proficient in Zulu. The answers were then marked and coded by the researcher. The answers that needed translation were mostly short sentences. Single words or names and numbers filled in on tables or graphs were the same for both English and Zulu. The

questions and categories used in the test are summarised in Table 5 (page 60). A copy of the English test and mark scheme can be found in Appendix 1 and the Zulu test can be found in Appendix 2.

#### 3.2.3.1.5. Analysis of results

Results were entered into a spreadsheet programme, Microsoft Excel, where sorting took place. Statistical analysis took place using the programme "Statview" (Abacus Concepts)

Table 5: A summary of the science questions and categories used in the skills assessment test.

QUESTION No.	APU QUESTION NAME	CATEGORY	SUB-CATEGORY	EXPLANATION
		SYMBOLIC REPRESENTATION		
1. 2.	OKAPI BUTTERFLIES		Reading information presented in various forms	Info in the form of Venn diagram and table
3. 4.	WET LOG FLOW RATE		Adding information to partially completed graphical representations	Plotting points on a given set of axes. Adding flow rates onto a table.
		APPLYING SCIENCE CONCEPTS		
5. 6. 7. 8.	TADPOLE DISAPPEARING SALT MICKY'S TRUCK CIRCUITS			Require pupils to recall and use relevant science concepts and knowledge in making predictions or suggesting explanations of given info
		INTERPRETING PRESENTED INFORMATION.		
9. 10.	BRIDGE SPAN TREE RINGS		Assesses the ability to use and make sense of information.	Includes finding patterns in information, making predictions, drawing conclusions and giving explanations.
		PLANNING PARTS OF INVESTIGATIONS		
11. 12.	WALLS THREADS		Assesses the skills used in planning how to find things out, solve problems or test ideas.	Can concern the control of variables, procedure, criticism of methods and improvement.

### **3.3. ASSESSMENT OF STANDARD FIVE CONTENT**

This was a test taken by all standard 6 pupils at the end of January 1996. It was used to try to assess the pupils' understanding of various common science terms and concepts encountered in primary science. It also aimed to assess their familiarity with certain pieces of equipment which should have been used or at least demonstrated in standard 5 science.

#### **3.3.1. SAMPLE SIZE AND SAMPLING PROCEDURE**

The tests were administered to all standard 6 pupils present at school on the day the test was written in January, 1996. All classes took the test since the information was important for each science teacher and the classes she/he was teaching.

The results used for discussion in this section of the research (content assessment) will be limited to the 3 classes taught by the researcher. These classes were 6A (40 pupils), 6B (38 pupils) and 6C (36 pupils). It is felt that these classes still represent a random sample of the entire group of standard 6 pupils. The reasons for this are:

- The researcher had no role in the choice of classes assigned to her for teaching. Classes were randomly assigned to each teacher by a member of the administration staff.
- The three classes in the sample contained English first and second language learners in almost the same proportion as the entire standard 6 population i.e. approximately one third English first language learners and two thirds second language learners.

- These results would not be biased by the researcher as practitioner in this situation, since the tests were taken prior to the start of formal science instruction in standard 6.

### **3.3.2. WRITTEN TEST ON CONTENT**

#### 3.3.2.1. Compilation of the test questions

The test was compiled by two standard 6 science teachers. They identified various specific biological terms, concepts and apparatus that should have been covered by the end of standard 5, as laid out by the general science standard 5 syllabus in use in KwaZulu - Natal. They drew mainly on those areas which relate to work to be covered in standard 6. The test can be found in Appendix 3.

#### 3.3.2.2. Administration of the test

1. The test was taken in January by all standard 6 pupils present at school on the day the test was written.
2. The test was completed during a normal general science period of approximately 45 minutes. In a few instances some pupils were given extra time if the need arose.
3. The test was administered by the three standard 6 general science teachers in their own classrooms.
4. The test was written in English only.
5. All questions were given a numerical score. All teachers used the same mark scheme to mark the classes that they taught.

The decision to write the test in English only was primarily because the test dealt mainly with more specific scientific terms. It was felt that the majority of these terms were

used, when teaching, in their English version, even when discussion or further explanation took place in the mother tongue. This was confirmed in discussion with second language learners. It is however acknowledged that some language bias might still affect the performance of second language learners as regards the understanding of instructions rather than specific science terms.

### 3.3.2.3. Analysis of results

It was important in this research, to use pupil responses, correct or otherwise, to assess their understanding of some basic biological terms and equipment used in standard 5 science. Responses were coded to detect common errors. They were also used to indicate which parts of the standard 5 content and equipment were more familiar to pupils and which areas seemingly less familiar to them.

## **3.4. PRIMARY SCIENCE BACKGROUND – STANDARD 5 TEACHER'S PERCEPTIONS**

The aim was to try to establish the formal primary science background experienced by the pupils in their feeder schools. It was also important to try to establish what the primary science teachers thought their pupils were capable of doing on entry to high school science, i.e. what science skills they thought their pupils possessed by the end of standard 5. It was established, from official records, that the standard 6 pupils came from over 90 different feeder primary schools. The schools are located in both urban and rural areas of the greater Pietermaritzburg and Midlands region of the KwaZulu - Natal Department



of Education and Culture. A small percentage (less than 5%) of pupils had transferred from schools outside this region.

#### **3.4.1. SAMPLE SIZE AND SAMPLING PROCEDURE**

Considering the number of schools mentioned and their physical location, it was not possible for the researcher to make personal contact with all feeder schools. Problems of lack of telephone services and unreliable postal systems in certain areas were encountered. The researcher also experienced some difficulty in obtaining a list of addresses of all the feeder schools from official sources.

Taking these factors into account then, the researcher decided to use a sample of primary science teachers based on those teachers it would be possible to contact via standard 6 pupils still residing in the area of their primary school. These pupils were established and a reliable pupil was given the responsibility of delivering the questionnaire to the primary school. The researcher was also able to hand-deliver questionnaires to 4 schools within the immediate vicinity. In total 30 questionnaires were handed out.

An obvious disadvantage of the 'courier' system used here is the reliability of the pupils to carry out the task. The alternative (postage) however did not hold promise for greater returns. Since the researcher could make frequent contact with the pupils to check on delivery, teacher response etc. it was decided that this system was the better option.

### 3.4.2. RESEARCH TECHNIQUE

The questionnaire is quite commonly used as a data collection technique for surveys conducted in education. The questionnaire was chosen as a research tool in this instance mostly because the target population was scattered over a wide area. Studies involving questionnaires often come under criticism for a variety of reasons. Some listed by Wiersma (1980) are as follows.

- There is excessive non response.
- Respondents are not truthful in their responses.
- Items are poorly constructed and /or organised.
- Data from different questions is difficult to synthesise.

The researcher did experience a fairly high degree of non response which then demanded more stringent follow-up procedures. Any discrepancy between what teachers said they had covered or thought that their pupils were capable of doing, was picked up by the performance of pupils in the various tests administered.

#### 3.4.2.1. Questionnaire construction

The questionnaire (see Appendix 4) was limited to three pages and sought information which covered the following areas.

- General information on the teacher: age, gender, qualifications and science teaching experience.
- Formal science teaching environment: time, textbooks, equipment available, language policy for science teaching and content covered.

- Projected skills: what the teachers thought their pupils were able to do on completion of standard 5 science.

The more general questions in the questionnaire required very direct, short answers (e.g. “name textbook used” or “state qualifications”). Other questions were forced response items which required placing an X in the appropriate column. Forced response items are thought to have the advantage of achieving greater uniformity of measurement and therefore greater reliability; of making the respondents answer in a manner fitting the response category and of being more easily coded (Cohen and Manion 1994, p.276). There is however the weakness of possibly forcing responses that are inappropriate because an alternative is chosen that does not accurately represent the true facts.

To try to avoid some of the criticisms and weaknesses mentioned already, the questionnaire was initially trialled in a group session with fellow science masters students, all of them practising science teachers. This was to try to determine how people were likely to answer. This was helpful and changes were made to question content, wording and form of response. Clarity of wording and simplicity of design were thought to be important.

#### 3.4.2.2. Administration of questionnaire

1. Permission for the use of questionnaires in the schools had to be obtained from the KwaZulu-Natal Department of Education and Culture.

2. A covering letter was included with each questionnaire. The letter used a more personal approach to explain the researcher's role and the significance of the questionnaire.
3. The sample was identified as explained previously.
4. Questionnaires were sent out during the first week of the third term. The first response was received 2 weeks later.

#### 3.4.2.3. Analysis of results

Questionnaires were analysed by the researcher. Because the return rate was so small, the researcher was able to count all responses to each question and categorise information without computer spreadsheets.

### **3.5. SCIENCE TEACHERS IN THE SECONDARY SCHOOL**

The researcher is a member of staff of the secondary school in which this assessment took place. As a standard 6 general science teacher herself, she was directly involved with the teachers within the science department. The researcher is mindful of this and acknowledges her position with the thoughts of Powney and Watts (1987), "a teacher carrying out an enquiry into an aspect of his/her own school will have separate but related roles as colleague, researcher and interviewer, roles which might impinge on and interact with each other" (p.7).

Qualitative methods of research have placed emphasis on analysing individuals' reactions within the normal context in which they might occur. The focus becomes the detail and

quality of an individual or small group's experience, rather than the number of people who responded in a particular way. It is this line of thought which guided the choice of technique in this area of the research.

### **3.5.1. STANDARD 6 TEACHERS QUESTIONNAIRE**

A questionnaire was chosen as a research tool with this group of teachers for 2 main reasons:

- it allowed the researcher to assess individual teachers perceptions of the issues at hand, without prior discussion with colleagues.
- it made individual teachers think of their own teaching practice and this would benefit the group discussion that was to follow .

#### **3.5.1.1. SAMPLE**

The questionnaire was specifically intended for completion by standard 6 teachers. As teachers rotate science teaching loads within the science department, all permanent science teachers at the school have taught standard 6 general science within the last five years. Hence both current general science teachers and those teachers who filled the five year criteria above, completed the questionnaire. Sample size was thus limited to five teachers.

### 3.5.1.2. QUESTIONS

The questionnaire can be found in Appendix 5. The focus of the questionnaire was two-fold. The researcher used open-ended questions to try to establish the teachers' ideas about science skills, especially in relation to standard 6 pupils on entry to secondary school. The open-ended format was chosen so as to allow teachers to make their own decisions about what counted as a skill, which skills they considered important or necessary, which skills they found commonly well developed and which skills they found mostly absent. In order to facilitate time and also offer some 'guidance' as to organisation and length of responses, the following type of table was used in the questionnaire.

Skills they OUGHT to possess	Skills they DO possess	Skills found to be ABSENT

This format was found to be beneficial in that teachers had to decide on their own list of what they considered as 'skills', rather than tick off a list already supplied to them.

Another open-ended question used was the following:

"By the end of standard 6 I think a science pupil should be able to....." (with ample space left for an answer). The idea was find out which skills were contained in their responses, and then to see whether these matched their discussion in the group interview.

Since almost 60% of the standard 6 pupils are learning science in what is for them a second language (i.e. English), and since this research used tests in both Zulu and English, the researcher also used the questionnaire to probe some of the teachers' views

as regards science teaching and second language pupils. The focus of the research was not the specifics of second language science teaching, but language was a factor that had to be considered in this situation if assessment was to be meaningful.

Often the disadvantage of open-ended items is that the answers are usually more difficult to tabulate and synthesise than those of forced response items (Wiersma 1980, p.148). In this case the open-ended format was chosen to allow more freedom of response. The sample was also small (relatively) and this was thought to reduce the synthesis problem somewhat.

### **3.5.1.3. ANALYSIS**

Questionnaires were analysed by the researcher. Information supplied was sorted to try to establish what skills the standard 6 teachers thought the pupils did possess on entry to secondary school. This was compared with what the standard 5 teachers thought their pupils could do by the end of standard 5. It was also necessary to establish what skills the standard 6 teachers thought the pupils ought to possess, since these would probably be the ones they would not teach or 'reteach' anyway.

### **3.5.2. GROUP DISCUSSION WITH SCIENCE TEACHERS**

The group discussion was chosen to allow discussion to be developed so that a number of responses could be collected. The group consisted of teachers who have been working together for some time, and it was important that everyone concerned was aware of what others in the group were saying.

### 3.5.2.1. INTERVIEW.

3.5.2.1.1. TYPE: The interview held could be classified as a focused interview i.e. “while seeking to follow closely the principle of non-direction, the method does introduce rather more control in the kinds of questions used, and sought to limit the discussion to certain parts of the respondents experience” (Cohen and Manion 1994, p.289). Basic questions to be covered were set by the researcher prior to the discussion, although the sequence of questions and subsequent discussion was not strictly controlled. (See Appendix 6)

3.5.2.1.2. SAMPLE: The researcher invited all teachers in the science department to the discussion. Two teachers were temporary replacements who had only started at the school within the third term and so did not attend. One teacher was not available on the day. Hence 4 teachers attended the discussion and all have taught general science.

### 3.5.2.1.3. ADMINISTRATION:

1. Colleagues were approached beforehand to try to establish a time suitable to most people. It was emphasised that the discussion would take at least an hour and thus a time outside the normal school routine would be more practical. The purpose for the discussion was explained to individual teachers and a suitable time and location was fairly easily established. The group discussion took place at the school at the beginning of October 1996.
2. The researcher drew up an interview schedule which was used to loosely direct the discussion. The three broad areas highlighted by the researcher beforehand were:
  - a) results of skills assessment test
  - b) are we teaching skills?
  - c) is there any plan of



action for meeting the needs of official departmental skills-based assessment to be introduced in standard 7?

3. On the day of the interview the researcher arrived at the research school early enough to arrange suitable seating in one of the science rooms. The tape recorder was set up for data collection. The reason for recording was explained to the teachers and the researcher found that the discussion was in no way hampered by the device.

Since a time had been decided upon prior to the discussion (i.e. one hour) the researcher found that the discussion was able to proceed uninterrupted with teachers joining in the discussion freely. The researcher posed the questions to direct the discussion, but found the roles of colleague, researcher and interviewer somewhat conflicting. The interview was recorded on tape and the researcher made a few notes if something struck her as being important to consider in analysis. After 70 minutes a teacher needed to leave and this then signalled the end of the discussion. Other teachers still continued to engage in discussion. The total time spent with the teachers was 90 minutes.

#### 3.5.2.1.4. ANALYSIS

The researcher recognised the fact that the analysis should be consistent or compatible with the general underlying philosophy of the research. As outlined in the introduction, the researcher was using qualitative methods to focus on the detail and quality of the teachers' experience. Hence more descriptive methods of analysis were used for the group interview. The researcher listened to the entire tape recording of the interview a few times, and this then provided a context for the emergence of specific units of

meaning and themes. A summary of the main points raised by the group was then drawn up.

## **CHAPTER FOUR**

### **ANALYSIS OF RESULTS**

#### **4.1. RESULTS OF ASSESSMENT OF SOME SCIENCE SKILLS**

The mean scores obtained by pupils for each question and category of skill can be found in Appendix 7. The coding scheme used for the pupil responses as well as the number of each type of response made can be found in Appendix 8.

##### **4.1.1. SUB-CATEGORY: READING INFORMATION PRESENTED**

###### **QUESTION 1. (Okapi)**

This question presented information in the form of a Venn diagram. This form of representation required pupils to operate within the logic of classes and with the convention of representing these by the overlapping regions of circles.

15% of all standard 6 pupils who took the test provided a correct response for this question. The non-response rate was 27% of the total pupil population. The most common errors showed a misunderstanding of the concept of the Venn diagram. This resulted in 47% of the pupils supplying examples and/or characteristics for each group stated in a circle. The remaining pupils in the sample (11%) also performed poorly, stating definitions or facts unrelated to the question.

The results suggest that most standard 6 pupils are not familiar with the presentation of information in the form of a Venn diagram. This is in spite of the fact that the issue of sets is covered (supposedly) in standard 4 mathematics. The possibility exists that:

1. The pupils were not taught Venn diagrams as a method of presenting information.
2. The pupils may have used this method in mathematics, with mostly numerical data. If the concept was not properly understood, then the pupils will have difficulty in making the transfer to another subject (in this case General Science) or to a more descriptive form of data.

It is not possible to state which of these two reasons might be responsible for the low correct response rate in this question without talking to both pupils and their primary school mathematics teachers.

### **QUESTION 2. (Butterflies)**

The question used presented mostly verbal descriptive information (as opposed to numerical data) in the form of rows and columns. "The main demand seems to be care in not straying from the correct rows and columns, once they have been identified" (APU 1982, p.168).

30% of the total sample produced correct responses for the table. The non-response rate was 5% of the total sample. This rate was much lower than the non-response rate of question one, suggesting that the pupils were more familiar with information presented in the form of tables than with the Venn diagram. 41% of the total sample showed an apparent misunderstanding of how to read information presented in the form of a table. This was the most common error. The pupils were not able to locate the required cell in

the table, differentiate between rows and columns or move to different cells within the same row or column. Examples of errors made by the pupils will illustrate this. Question (a) asked "What is the foodplant of the Swallow-Tail Butterfly?" A pupil who answered incorrectly with Bird's Foot Trefoil is able to locate the correct column (i.e. food plant), but the incorrect row: the correct answer is in fact in the cell directly below. However, certain responses indicated that the names of the butterflies and food plants were not common to the pupils and hence caused confusion. Question (b) asked "Which butterfly's eggs take longest to hatch?" The pupil who answered 'Nettle' showed that they did not identify this as a plant and hence it was just as easy for the pupil to assume that it (nettle) could be the name of a butterfly.

One needs to highlight some factors which should be borne in mind when interpreting the above results. The amount of descriptive information in the table may have confused pupils not completely familiar with or confident about manipulating data presented in rows and columns. As pointed out before, it is also possible that these pupils are not familiar with the mostly British butterfly and plant food names used, and this could also have caused some confusion, although it should not have seriously affected the basic understanding of the table. Questions raised by some pupils during the assessment indicate that the main hurdle is the basic workings of a table. The following experience of the researcher illustrates the point. A pupil raised her hand during the assessment in one class and asked the question ".....which way does the table go, this way or that way?" (Hand gestures indicating down and across). Most of the pupils in the class nodded vigorously, as though in agreement with her question.

Both Question 1 and Question 2 represented a single sub-category i.e. reading information presented in some organised form. Results for overall performance in this category are presented in the form of histograms. In Figure 2 histograms are provided for performance of 4 different groupings within the total standard 6 sample. These groupings are as follows:

- a) the scores for the total sample writing in English (the medium of instruction in the school);
- b) the scores for the English first language pupils writing in English;
- c) the scores for the second language pupils writing in English; and
- d) the scores for the second language pupils writing in their mother-tongue i.e. Zulu.

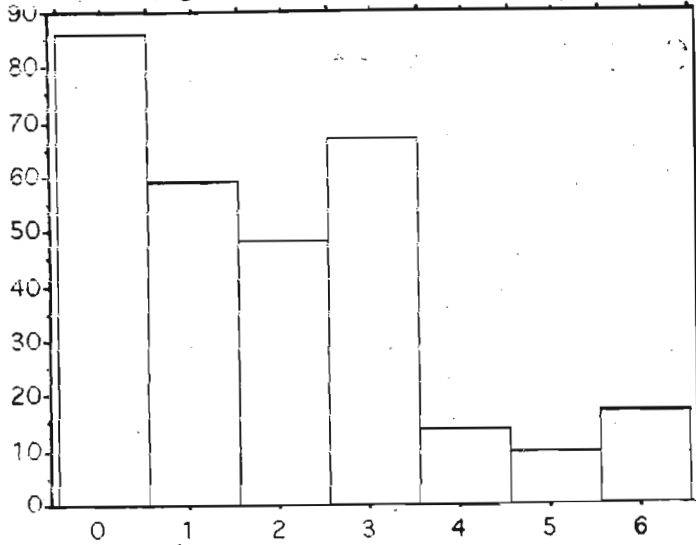
The discussion which follows refers to the histograms found on page 78. The histograms are arranged side by side to facilitate comparisons as pointed out in the discussion.

Histogram A, which shows the scores for the total sample, indicates that 0 is the most common score. The 0 responses include both incorrect answers that scored no marks as well as blank spaces. The next most common score is 3, with the number of pupils obtaining less than 50% much greater than the number of pupils who obtained more than 50%.

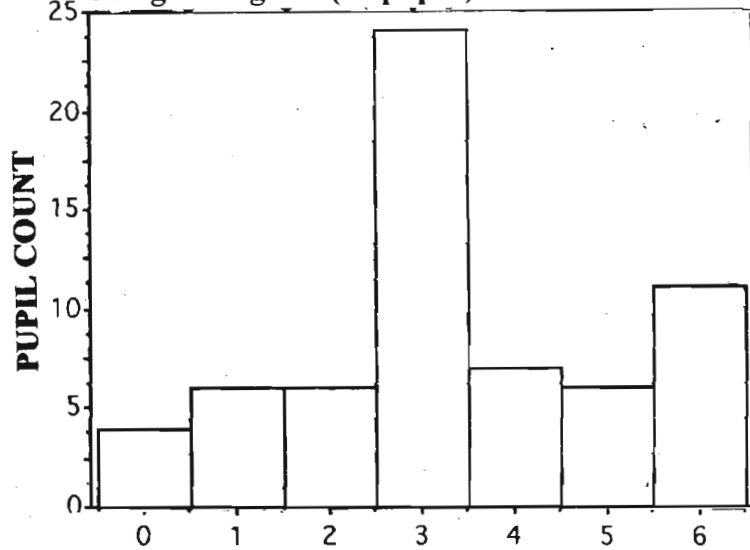
Figure 2. Pupil scores obtained in the sub-category **READING INFORMATION**

(Questions 1 and 2)

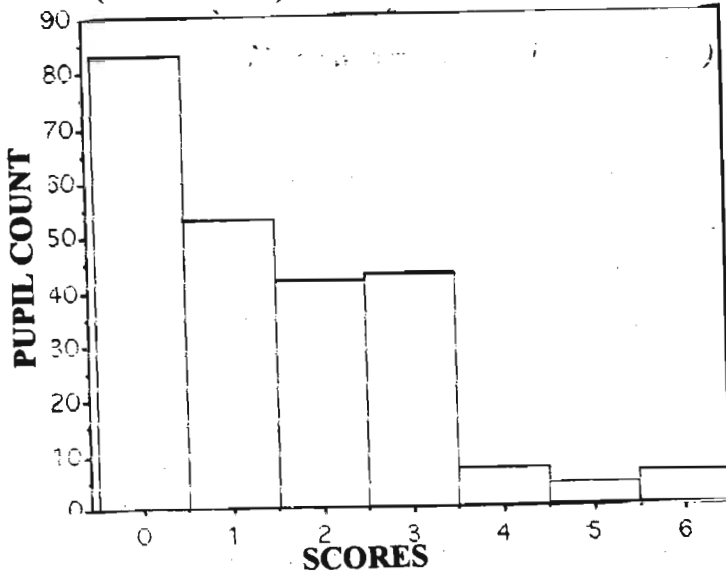
**A. Scores for total sample writing in English. (302 pupils)**



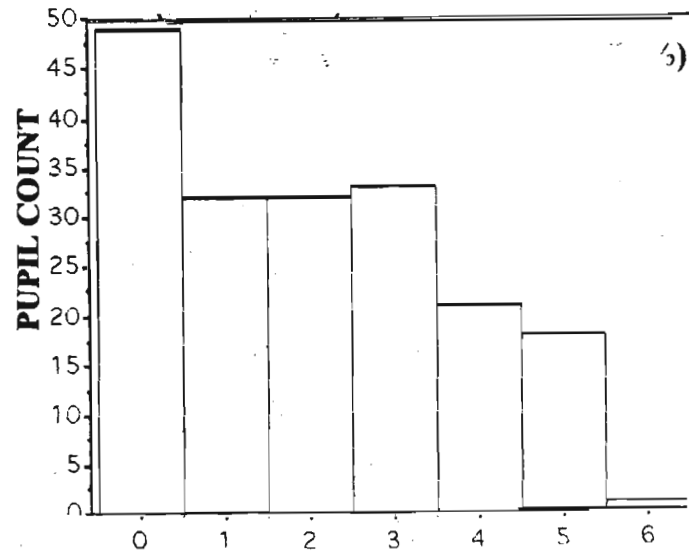
**B. Scores for first language pupils writing in English. (66 pupils)**



**C. Scores for second language pupils writing in English. (236 PUPILS)**



**D. Scores for second language pupil writing in Zulu (186 PUPILS)**



Histogram A actually masks the results shown in B. Here we see the performance of a group of pupils whose first language is English and who have written the test in their first language. The number of 0 scores is markedly reduced when compared to the total sample. The number of pupils scoring more than 50% for the test is also increased for this sample. Histogram D shows the results of English second language pupils who

completed the test in their mother-tongue i.e. Zulu. The results obtained suggest that even though both groups have written the tests in their mother-tongue, there is still a marked difference in performance of reading information from the various formats presented. One also notices an improvement in performance, especially with regard to question 1, when the second language pupils answered the test in Zulu as compared to the results obtained when the test was presented in English. The mean scores for question 1 more than doubled when the test was taken in Zulu (11% to 28%). The mean score for question 2 also improved, although not as much as for question 1 (37% to 40%).

#### **4.1.2. SUB -CATEGORY: ADDING INFORMATION**

##### **QUESTION 3. (Graph)**

This question illustrates a question type where pupils scored at a very much lower level than either question 1 or 2. Pupils had to add 3 points to an incomplete graph provided to them. The axes were already drawn and labelled for the pupils.

All 3 points were correctly plotted and joined by 0.9% of the total pupil population. A further 0.9% plotted the correct points but did not join them. This question recorded a non-response rate of 73%. The rest of the pupils who attempted to answer this question simply drew lines in various directions e.g. beneath the lines already drawn, from the last point plotted and some from the mass axis. These attempts showed that the pupils had very little understanding of graph construction or making sense of information presented in this form.



The very high non response rate seems to suggest that these pupils are not familiar with graphs. Manipulation of graphs is a specific skill which they would need to have been taught rather than something they would have learnt incidentally. Discussion with the standard 6 General Science teachers revealed that they had not used graphs at all with their pupils within this year (1996), even though some of the content covered allowed for presentation and use of graphs. Mathematics teachers also revealed that they would not expect these standard 6 pupils to be able to add points to a graph since this skill is not developed in primary school mathematics. This factor then would explain the high non-response rate for this question. It is however interesting to note that 6 out of 10 standard 5 teachers thought that, at the very least, 25% of their pupils would be able to plot points on a graph. Two teachers thought that more than 50% of their pupils would be able to plot points on a graph. The researcher used this question mainly because a study of pilot test papers for standard 7, sent to the school by the Department of Education and Culture in 1996, showed an emphasis on information presented mostly in different graphical forms. It was thus considered necessary to find out pupil capabilities in this area. For this particular group then, the ability to draw and interpret graphs will have to be developed in standard 7 by both the mathematics and science teachers if the pupils are to be able to make sense of the type of graphical representations expected of them by the end of standard 7.

#### **QUESTION 4 (Flow rates of different liquids)**

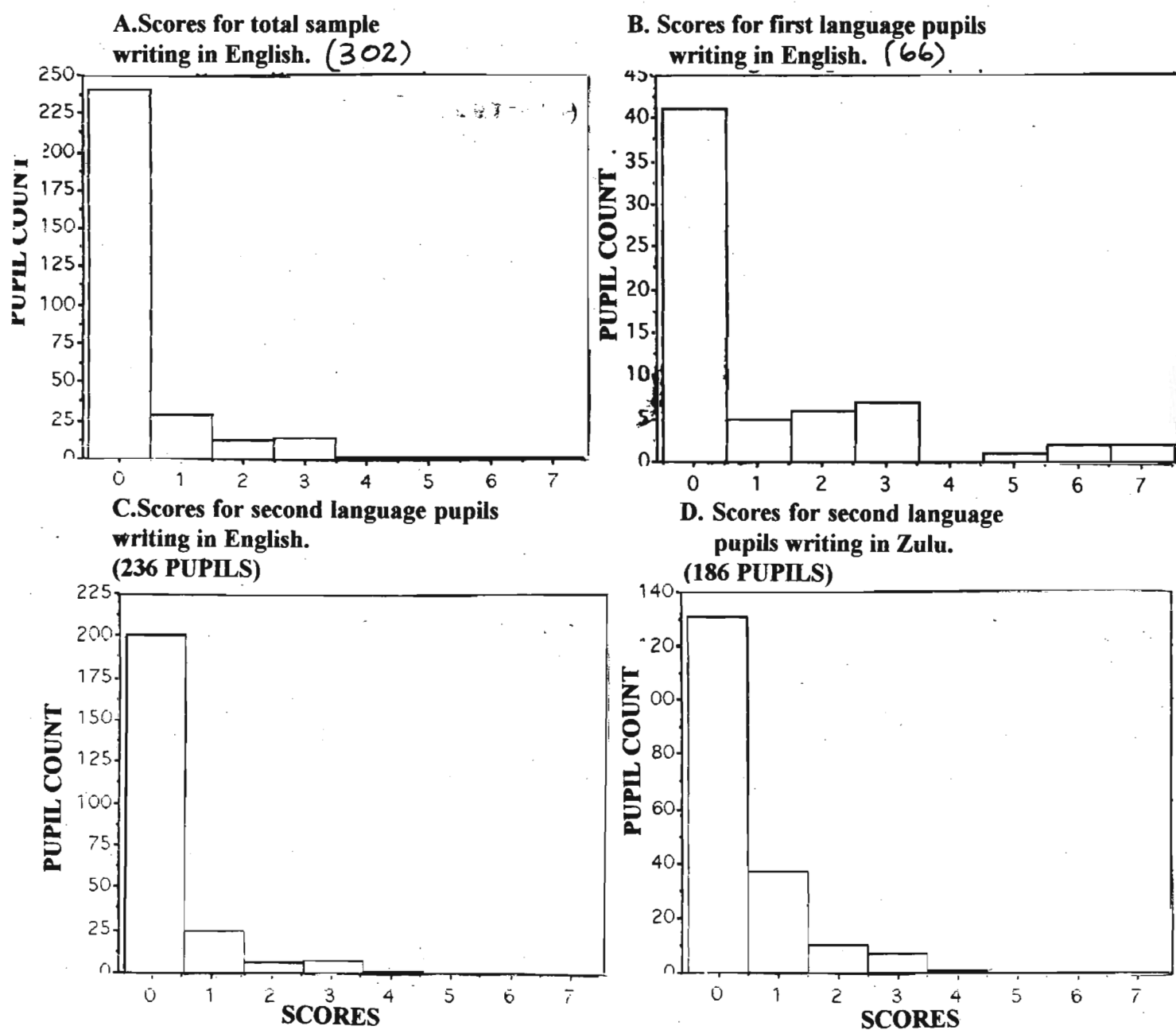
This question required pupils to add numerical data to a table supplied. Like the graph exercise, it required pupils to co-ordinate vertical and horizontal locations in the table.

7% of the total pupil sample were able to fill in the numerical data in the correct space in the table. This is a very low correct response rate for a question type which is commonly used in science teaching and testing. The non-response rate for this question was 33%. 58% of the pupils filled in some or all numbers required, but in the wrong positions in the table. This indicates that the main problem is still how to co-ordinate rows and columns as was the case with reading information from the table supplied in question 2. In this question, to locate a particular cell in the table, pupils were required to consider 3 factors at the same time i.e. height, time and type of liquid. This could have caused some confusion for pupils not familiar with working manipulating information presented in table form. The remainder of the pupils (about 2%) filled in descriptive data instead of the numbers supplied, e.g. yes or no, names or even explanations. These descriptive responses suggest that this group of pupils did not understand the question in the first place and hence could not respond in an appropriate manner. These responses were made by second language pupils, which is a strong indication that the language of presentation was the main problem.

When studying the histograms (page 82) which represent the overall scores obtained in the sub-category adding information, the most striking feature common to all pupil groupings is the large number of 0's. 53% of these are null responses. This 0 response is very noticeable even when pupils take the test in their respective mother-tongue languages. This would seem to indicate that this skill area was very poorly developed in all pupils at the time that the test was taken. Pupils generally performed better on question 4 than on question 3. It has to be acknowledged that it seems more than likely that pupils have not been formally taught graphing skills in primary school and this would

then account for the very high non-response rate. One would however have expected pupils to have performed much better in the question using tables. Once again second language pupils showed an improvement in results when the test was presented in the mother-tongue, with a slight improvement in both questions.

**Figure 3. Pupil scores in the sub-category ADDING INFORMATION (Questions 3 and 4).**



#### **4.1.3. SUB-CATEGORY: APPLYING SCIENCE CONCEPTS**

This sub-category assesses pupils' ability to make sense of the information presented in a question in the light of relevant science concepts and knowledge. In order to give a satisfactory answer pupils need to recall and then use these ideas.

#### **QUESTION 5 ( Frog life cycle)**

This question presented data of the life cycle of the frog in a pictorial form. Pupils had to decide on the correct sequence of events. No written explanations were required.

44% of the total pupil sample was able to place the drawings in the correct sequence. The non response rate was 19%, which still seems too high for a question that relied mostly on pictorial data which clearly showed differences in each developmental stage. The frog was also covered in the standard 5 syllabus. One would be inclined to think that these pupils did not understand the instruction (language?) rather than the drawings. 30% of the pupils did not seem to understand the concept of sequence or ordering because they provided labels for the drawings, or more commonly provided short explanations of each drawing. It is also possible that they just followed their normal science routine for answering school science questions instead of spotting that something different was asked for.

#### **QUESTION 6 (Dissolving salt)**

This question related to the general idea that some things dissolve in water and others do not. This question presented a situation and asked for an explanation. Data was provided in pictorial and verbal form.

5% of the total pupils sample provided partially correct answers to this question. Very few pupils used the word 'dissolved' to explain why the salt disappeared. The word more frequently used by the group of partially correct respondents was 'melt' which appeared to be synonymous with 'dissolve'. The most common error here was to provide an explanation for why the salt would disappear and then totally ignore an explanation for why the other solids did not disappear. Hence most answers were only partially correct. The non-response rate was 27%. A smaller group of pupils (2%) used the more physical differences between sand and salt to explain why the salt disappeared e.g. "salt is light and sand is heavy / salt has small particles compared to sand". The majority of responses (57%) were mostly single, incorrect statements that did not explain why one would dissolve and the other not e.g. "because salt is an acid / because salt has big air spaces / because salt is a solid". Here again the pupils are ignoring the second part of the question.

It is possible that the pupil responses were influenced to some extent by the pictorial information which showed beakers and funnels. This might have given the situation a very 'scientific' context and pupils were thus inclined to provide some response they would regard as scientific. Pupils not familiar with the apparatus may also have felt threatened and thus chose not to respond to the question. One needs only to refer to the equipment section of the content test (page 99) to realise that this might indeed have been a factor. It is possible that more pupils would have answered correctly had the pictorial aid related more to the daily context of their lives.

**QUESTION 7 (Mickey's truck)**

This question was set in an everyday context and asked pupils to use the concept of energy. In order to give a satisfactory answer to this question, pupils had to use the idea that a wound spring is a source of energy and apply it in question about the transfer of energy. The first part (a) was a multiple choice question that required pupils to place a tick in the box of their choice. Part (b) required them to provide an explanation for their choice.

17% of the total pupil population indicated that the truck had the most energy after it had been wound up. This was a multiple choice type question so one cannot say for sure how many of these pupils actually understood the concept of energy in a wound spring. This is made more difficult by the fact that very few of the pupils were able to provide a correct answer to both parts (a) and (b). 33% of the responses indicated that the truck had the most energy when it was moving. APU surveys in 1982 found that 30% of their total sample thought that the truck had the most energy when when it was moving along (p.107) The pupils seem to think that it is the movement that is generating the energy and the winding of the spring has no significance for them at this stage. 10% of the responses indicated that the truck had the most energy before it was wound up. 16% of the pupils ticked more than one answer. It is likely that this group of pupils did not know how to answer multiple choice questions, nor did they understand the particular concept of energy being investigated. Most pupils failed to answer part (b) and when they did the answers very often did not relate to the concept of energy e.g. "...because it was moving along nicely..... because the truck was in a good condition..... because it has more speed than other cars."

**QUESTION 8 (Electricity)**

This question dealt with electrical circuits. Pupils had to recall their ideas about electrical circuits, especially that a complete circuit of conducting material is needed before electricity will flow. Predictions had to be selected by means of ticks. No explanations were required.

39% of the total pupil sample did not provide any response to this question. 11% of the pupils were able to identify both the complete circuits. An answer was taken as correct only if both circuits were identified. 22% of the responses indicated either A or C, but not both. Circuit C was a more popular choice than circuit A in this group. It is possible that pupils were confused by the fact that the wires in circuit A appear to be crossed over each other, while those in C appear to form a 'neat' pathway. The rest of the sample (28%) ticked one or more incomplete circuits.

It is possible that pupils have not studied electrical circuits. In standard 5 they dealt with electrical energy as one form of energy as well as energy transformations that involved light bulbs and the electric motor. Much would depend on the approach used by the primary science teacher in this regard. There is also the possibility that many of the pupils do not have electricity in their homes and are therefore not familiar with electrical circuits.

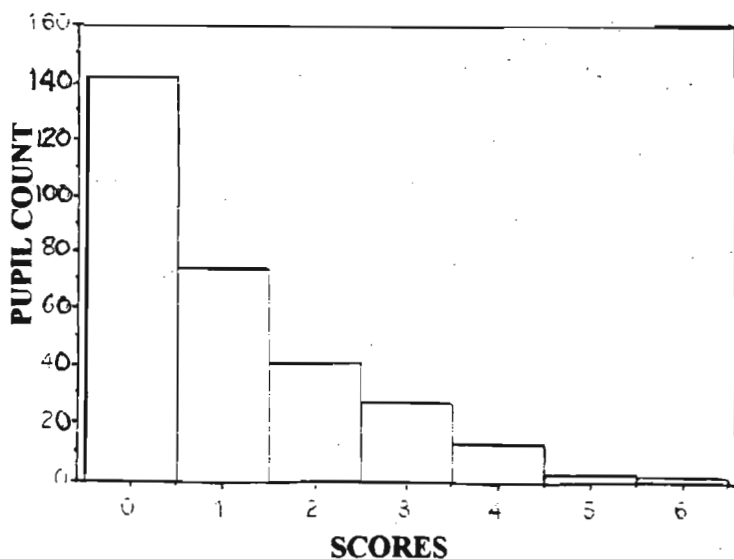
When studying the histograms depicting overall results for the sub-category **applying science concepts**, (page 87-88) certain features are in common with other sub-categories discussed so far: the high number of 0 scores and the decreased number of scores in the

4,5, and 6 range. One other point is once again shown in this category and that is the fact that pupils are performing much better when writing in their mother-tongue. The English first language pupils are still recording a much lower number of 0 scores and a higher number of scores above 2. But a more significant difference in performance is achieved in this sub-category between second language pupils writing in their mother-tongue and writing in English. When the pupils took the test in Zulu the number of 0 scores was markedly reduced, so that the most common score for this group was then 1 (compared with 0 on the English test). There was also an increased number of pupils who obtained 2 and 3 marks on the Zulu test. Pupils seem more confident to handle science concepts in their mother tongue at this stage, with the most improvement shown in the question concerning the dissolving of substances. Mean score for this question improved from 3% on the English test to 33% on the Zulu test.

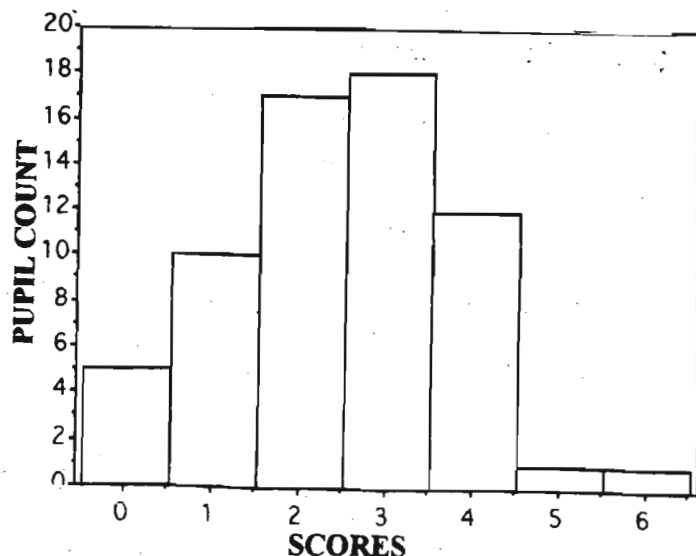
**Figure 4. Pupil scores in the sub-category APPLYING SCIENCE CONCEPTS.**

**(Questions 5, 6, 7 and 8)**

**A. Scores for total sample writing in English  
(302 PUPILS)**

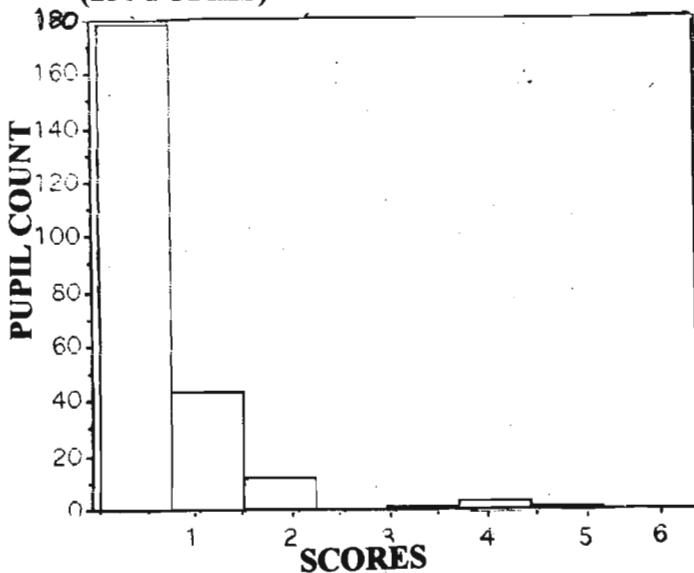


**B. Scores for first language pupils writing in English.  
(66 PUPILS)**

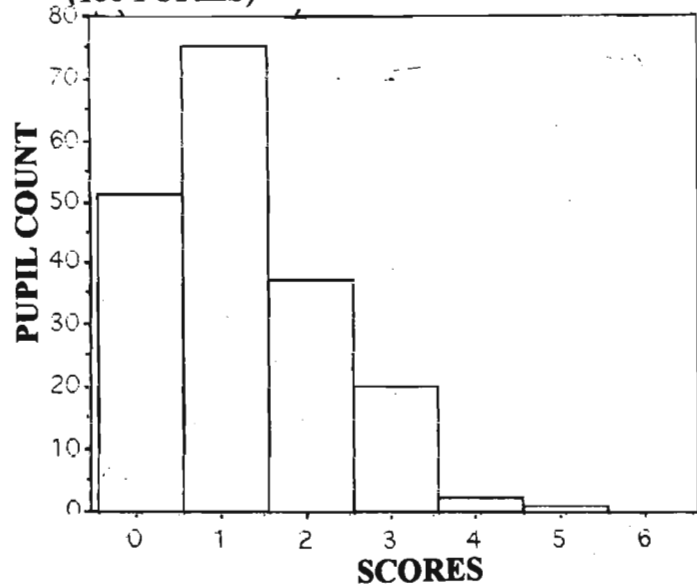




**C.Scores for second language pupils writing in English.  
(236 PUPILS)**



**D.Scores for second language pupil writing in Zulu.  
(186 PUPILS)**



#### **4.1.4. CATEGORY: INTERPRETATION OF DATA**

This category assesses the ability to interpret information when all the data are supplied.

It may involve picking out patterns in data, using the patterns to make predictions and sometimes drawing conclusions.

#### **QUESTION 9. (Bridge span)**

This question asked pupils to describe a pattern and supply a prediction. No prior knowledge about bridge structure and strength was assumed and the numbers were kept deliberately small so as to reduce arithmetic burdens.

The non-response rate for the total pupil sample was 56%. This seems to suggest that pupils simply do not respond to questions they deem 'foreign', in the sense that this is not something they recognise from their previous science content covered. Only 2% of the pupils were able to recognise a pattern between the span and the number of coins the bridge could support and this relationship was stated in various ways: "... as the number

gets bigger the less coins the bridge could support .... the more wider it gets, the less coins the bridge can support.... the span gets higher and the coins get lower”.

41% of the responses were incorrect and showed no understanding of the relationship between the span and the number of coins “..... he put all the small numbers second and the big numbers first.....multiples of 2 but from 18 downwards.....a triangle shaped pattern.”

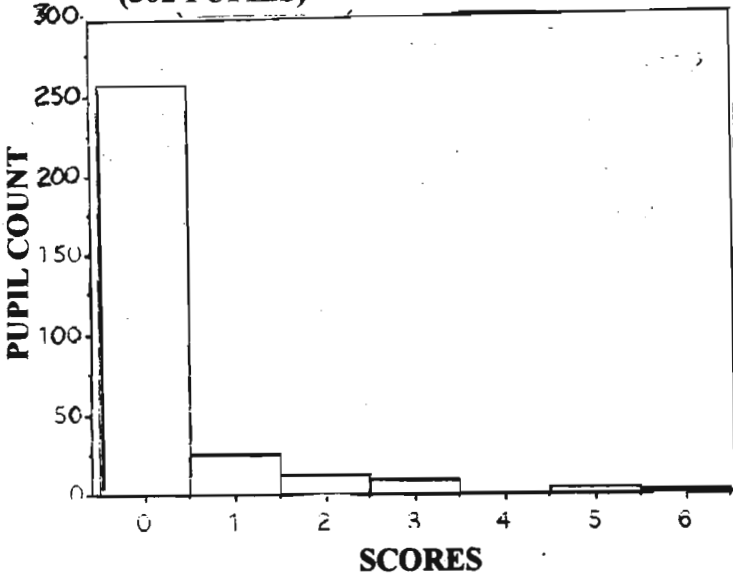
### **QUESTION 10 (Growth rings)**

This question presented information, via diagrams, about tree growth rings. It was not necessary for the pupils to know anything specific about growth rings since the relevant information was provided in the question.

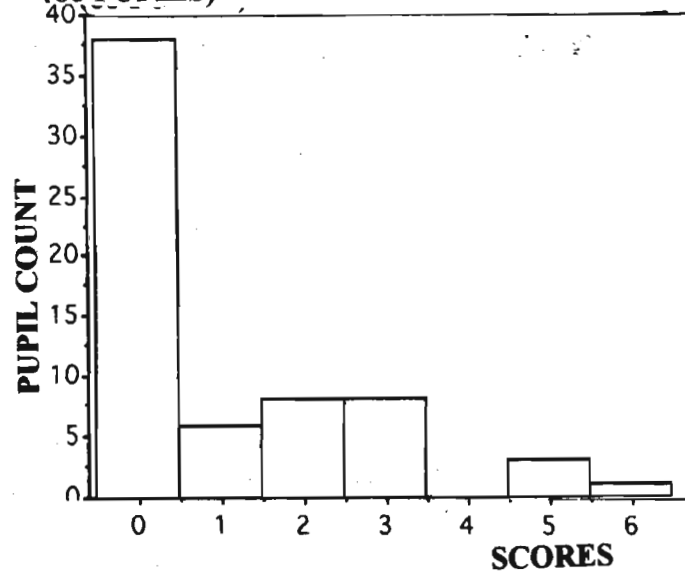
Although this question also sought to detect patterns in information, the non-response rate, although still high, 43%, was less than that for question 9. 3% of the pupils were able to recognise a relationship between the heights of the trees and the number of rings in the trunks. . “The higher the tree is the more rings it has..” 10% of the pupil sample were able to supply partial patterns. . “the third one has many rings and it is also the longest of the all..” 41% of the pupils supplied incorrect patterns or simply single statements “the rings get smaller everytime you cut down the tree.....some are tall and some have wide rings in the trunk”

Figure 5. Pupil scores in the category **INTERPRETATION OF DATA**. (Questions 9 and 10)

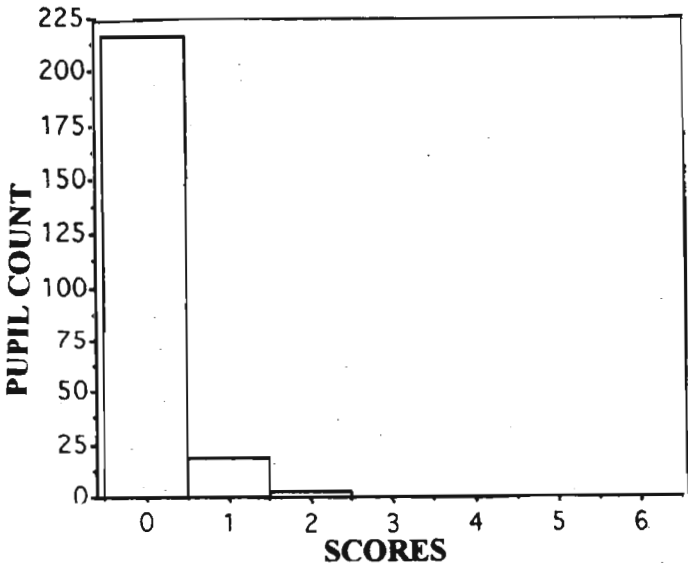
**A. Scores for total sample writing in English (302 PUPILS)**



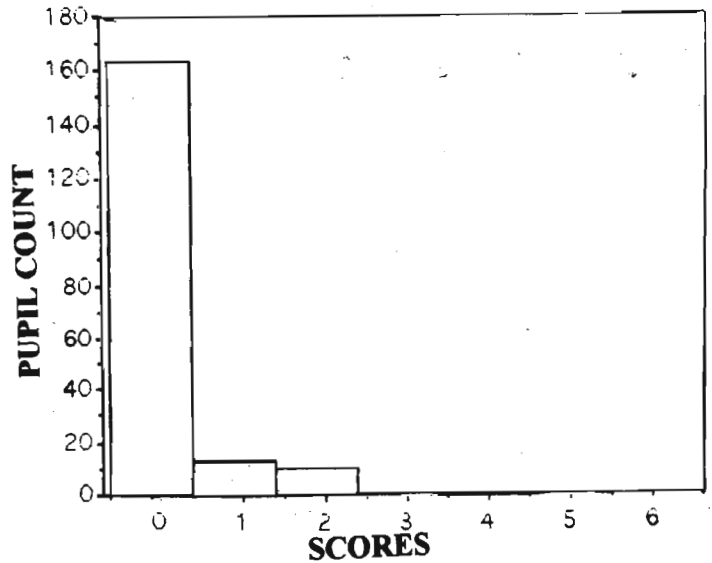
**B. Scores for first language pupils writing in English. (66 PUPILS)**



**C. Scores for second language pupils writing in English. (236 pupils)**



**D. Scores for second language pupil writing in Zulu. (186 PUPILS)**



Once again the most outstanding feature is the high 0 scores even for the groups writing in their mother tongue. There is not a significant difference in results for second language pupils taking the test in English or in Zulu. A very small number of English

first language pupils scored 5 and 6. These results suggest that the total pupil group had not had the opportunity, in their formal primary schooling, to develop the ability to interpret data by trying to seek patterns or state relationships.

The APU surveys found that performance in interpretation depended upon, amongst other things, the form of the data presented. Questions in which information was presented in numerical form produced lower performance than those in which information was presented in other forms (APU 1984, p.282). In this assessment, question 9 required pupils to identify a pattern from numerical data, whereas question 10 required a pattern identification mainly from pictorial data. If one looks at the mean scores for each of these questions (Appendix 7) it becomes evident that these pupils were able to perform better on question 10 (pictorial data) than on question 9 (numerical data)

Pupils also display very little confidence in this type of questioning, as indicated by the large number of non-responses. Remarks passed by some pupils after the test led the researcher to feel that the pupils may have felt threatened or even cheated by these types of questions. In response to the researcher's question about how the pupils felt about the test a pupil replied "...it was not nice. It was not about our work in standard 5. They were funny questions."

#### **4.1.5. CATEGORY: PLANNING OF INVESTIGATIONS**

This category is concerned with the pupils' skill in planning investigations. It involves them being able to recognise the various factors which may affect a result, identifying which factors to change and which to keep constant.

#### **QUESTION 11 (Threads)**

Pupils were presented with a test that had been carried out to determine whether nylon thread is stronger than cotton thread. A very clear, self-explanatory diagram showed the apparatus set up for the investigation. They were asked to suggest changes to make the test a more fair one.

68% of the total pupil sample did not respond to this question at all. 2% of the pupils did attempt to suggest changes that were acceptable. Answers that were unacceptable involved various kinds.

- a) Statements of obvious differences but not changes e.g. "one is long and one is short" (7%).
- b) Incorrect changes suggested e.g. "add vegetables.....cut thread with a knife" (10%)
- c) Facts stated singly, not suggesting changes e.g. "small pans.....cotton.....masses" (11%)

Other responses (2%) were incorrect but very varied and so did not fall into the groupings above.

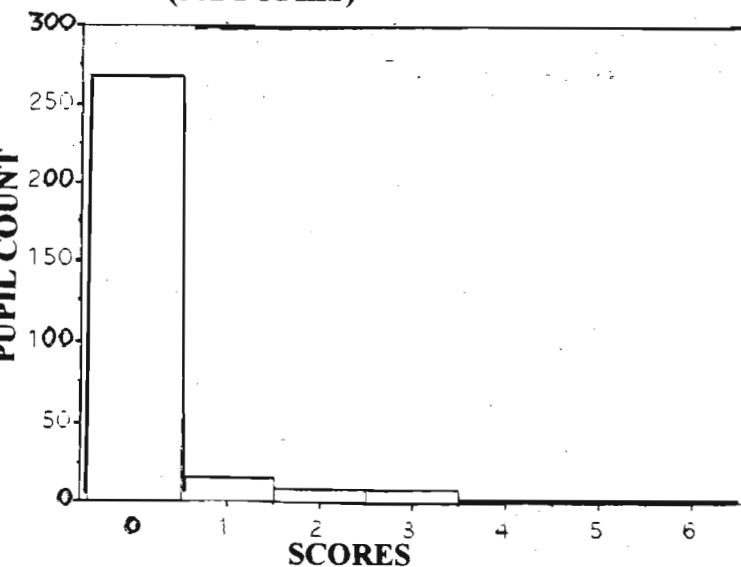
### **QUESTION 12 (Building a wall)**

In this question pupils were asked to identify 3 variables which should be controlled to make a given test fair.

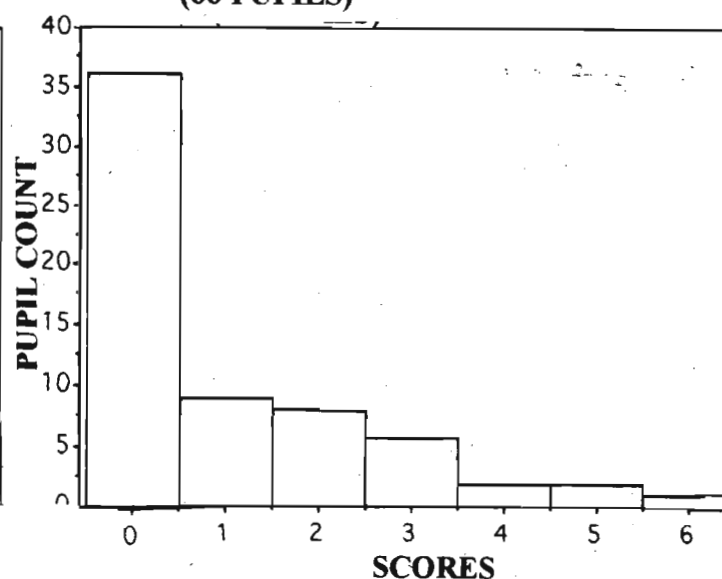
The level of non-response was very high (72%), once again indicating no confidence in dealing with this type of question. This is probably due to the lack of exposure to this type of questioning. 2% of the pupils were able to provide partially correct answers. Many pupils offered incomprehensible explanations which were not related in any way to the variables in question e.g. "paint the wall, ...do it neatly..... Derrick laughed when the wall fell over." Within this group, many of the answers provided seem to relate more to the pupils' personal experience of building a wall than to the situation stated in the question. E.g. "rather use windows and wood, ...use some cement and water.....you need a wheelbarrow to carry the sand". This is also in keeping with that found in the APU surveys, where it was noticed that "pupils tend to answer in terms of everyday experience rather than using the information supplied" (APU 1982, p252).

**Figure 6. Pupil scores in the category PLANNING INVESTIGATIONS. (Questions 11 and 12)**

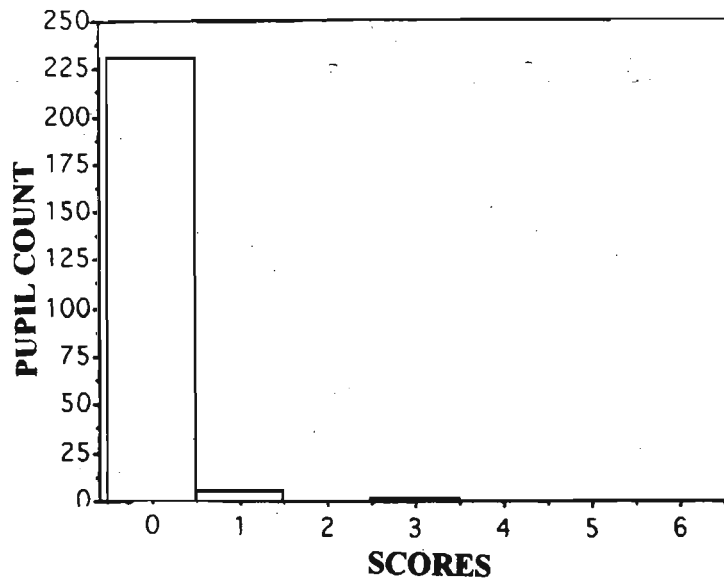
**A. Scores for total sample  
writing in English.  
(302 PUPILS)**



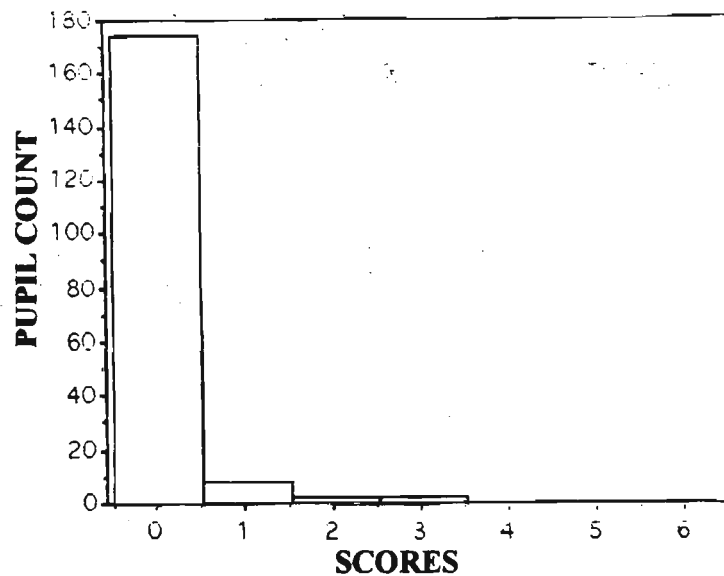
**B. Scores for first language pupils  
writing in English.  
(66 PUPILS)**



**C. Scores for second language pupils  
writing in English.  
(236 PUPILS)**



**D. Scores for second language pupil  
writing in Zulu.  
(186 PUPILS)**



The results for this category, as shown in the histograms, are very poor. The 0 scores are overwhelming, especially because in this category the number of pupils scoring anything more than 0 is negligible. Even presentation of tests in the mother-tongue has not made any difference for the second language pupils. The first language pupils still have a large number of 0 scores, but there are a few pupils obtaining scores ranging from 1 to 7. Literature reviews in chapter 2 and discussion with the science teachers (page 108) indicate that results in this category should not be entirely unexpected, given the traditional emphasis on learning 'right' answers in science education.

#### **4.2. ANALYSIS OF CONTENT ASSESSMENT TEST.**

This was a test taken by all standard 6 pupils at the end of January, 1996. It was used to try to assess the pupils' understanding of various common science terms and concepts

encountered in primary science. It also aimed to assess their familiarity with certain pieces of equipment which should have been used or demonstrated in standard 5 science.

### 1. Concepts of living and non-living (Question A)

Pupils were supplied with a list of organisms and they had to indicate whether the items listed were living or non-living. The types of responses that were made by the pupils are shown in the table below.

<u>Types of responses.</u>	<u>6A</u>	<u>6B</u>	<u>6C</u>
1. All living (correct answer)	43%	32%	19%
2. Plants non living / animals living	50%	50%	56%
3. Mixed answers (living and non living)	7%	13%	17%
4. Non-response	0%	5%	8%

From the table it can be seen that at least half of the pupils in each class assessed have a popular misconception that plants are non living while animals are living, this despite the fact that a great deal of time in primary science is spent teaching children about plant and animal life. It has been found that this is a popular misconception in young children (Driver et al.1994). The organisms used in the list provided were fairly common and within the daily experience of the pupils. Research in this area has found that “the more familiar the object, the more likely it was to be correctly classified” (Willig 1990, p.76). Teachers, in the group discussion with the researcher, were surprised by the results, since all seemed to assume that a pupil who enters secondary school will be able to distinguish a living organism from a non living object.

### 2. Terminology (carnivore, omnivore and herbivore) (Questions D, F, G)



These terms seemed familiar to many of the pupils with the 3 classes recording a fairly high number of correct responses : 75% for 6A, 66% for 6B and 53% for 6C. This would seem to suggest that most pupils had covered this section in primary science. Where responses were incorrect, it was commonly found that the terms were used, but used incorrectly e.g. omnivore instead of a carnivore.

### 3. Concept of growth in plants (Question H)

The question tried to assess pupils' understanding of what caused the tree to grow.

<u>Types of responses.</u>	<u>6A</u>	<u>6B</u>	<u>6C</u>
1. Statements using water, mineral salts and food.	50%	45%	19%
2. Statements which relate to structure or uses of trees e.g. seeds, internodes, to build nests.	15%	24%	36%
3. No response	35%	31%	45%

Water was the most commonly listed ingredient for growth. This supports what is said by Driver et.al. 1994, "...children, understanding that plants absorb water from the soil and that water is essential to growth, appear to assume that it is the main component of growth material" (p31). The frequent answers of soil and mineral salts seem to indicate that the pupils probably attribute the growth of the tree to the food taken in (from soil) rather than the idea that the tree makes its own materials from what it takes from the environment. Only one pupil used the term 'photosynthesis', although a small number of pupils did mention sunlight. They did not however relate the sunlight to food or photosynthesis, so one cannot be sure of the role they assumed the sun would play in growth.

#### 4. Feeding in mammals(Question J)

This question was answered very well by all classes with a mean of 73% for the 3 classes.

There was frequent use of the terms ‘suckle the young’, milk from mammary glands’. It indicates an area of content that pupils are familiar with.

#### 5. Concept of energy (Question K)

The question tried to assess pupil’s understanding of what provides energy for doing work, in particular, when a bird flies.

<u>Types of responses</u>	<u>6A</u>	<u>6B</u>	<u>6C</u>
1. Energy from food / seeds it eats.	30%	32%	25%
2. Energy from wind / air	4%	21%	34%
3. Energy from wings / feathers / sun	43%	39%	22%
4. No response	23%	8%	19%

The most common response seems to indicate that pupils associate energy with movement, and more specifically that the energy is generated by the movement. Hence they feel that the energy comes from that which is directly associated with movement i.e. wings and feathers and the wind. This was also the case in the skills assessment question on energy (see p85) where the most common response was that the truck had the most energy when it was moving.

#### 6. Question on the Pine (Question N)

This question was used to check if this section was actually covered in standard 5. It did not require any detailed knowledge since the pupils just needed to be able to identify a pine cone and realise it was part of a pine tree.

Type of responses.	6A	6B	6C
1. Correctly identified cone and /or tree	73%	18%	11%
2. Incorrect--did not recognise pine /cone	7%	32%	47%
3. Non-response	20%	50%	42%

In this question, which did not assess a general concept like growth or energy, but rather a particular group of plants which was in the standard 5 syllabus, a clear pattern of differences emerges. From the results one would assume that most of the pupils in standard 6A were familiar with the pine tree and cones. The results for the other two classes indicate that they are not familiar with the pine tree and its cones. The results are interesting if one looks at the dynamics of each class. The pupils in 6A come from 9 different feeder schools, with two thirds of the class coming from the same English medium feeder primary school. One can thus assume that the majority of these pupils (6A) then have a common primary science experience that has included learning about the pine. However, the pupils from 6B come from 25 different feeder schools and those in 6C come from 26 different schools, making it almost impossible to assume a common primary science for the pupils in each of these classes. The high percentage of incorrect and non response items suggest that these pupils are not as familiar with the pine. One possibility is that the pine was not taught in primary science. The other possibility is that they did cover the pine, but were never shown a real pine cone or pine tree, and that textbook drawings used were different from the one used in this assessment and that could have confused the pupils. One might also ask whether the pine tree is common to the various areas in which these pupils live, so as to be meaningful in the context of their

daily lives. It is interesting to note that all primary school teachers who returned questionnaires indicated that they had taught the pine in standard 5.

#### 7. Identification of equipment.

The table on page 100 records which pieces of equipment the pupils were able to correctly identify from diagrams supplied to them. The diagrams were clear and well spaced so that an incorrect answer or non response could not be attributed to physical layout of the worksheet. The results are not in anyway indicative of whether a pupil will be able to correctly manipulate the equipment in a practical exercise.

Some results were not entirely unexpected, given our knowledge of resources available in schools. Very low correct responses were obtained for the burette, pipette, measuring cylinder and scales shown. It is probably correct to assume that these were not available in schools, or if they were they were used in demonstration only. Correct identification of the microscope was also low, (much better than the test tube!) but also to be expected. 60% of the standard 5 teachers said they did not have microscopes in their schools. Many pupils who were able to correctly identify the microscope were not able to say what it was used for. Many pupils seemed familiar with the magnets, although slightly fewer with the thermometer and the metre stick. As regards the metre stick, most pupils used the terms 'measuring tape' or 'measuring rule(r)'.

Table 6. Identification of science equipment: percentage correct responses of pupils.

Equipment	Class 6A	Class 6B	Class 6C	Average
Magnets	85%	61%	28%	58%
Burette	8%	8%	3%	6%
Pipette	5%	11%	6%	7%
Measuring Cylinder	15%	0%	3%	6%
Microscope	43%	39%	25%	36%
Scales	25%	13%	6%	15%
Test Tubes	13%	21%	9%	14%
Beaker	25%	42%	45%	37%
Metre-stick	65%	45%	33%	48%
Measure a line	28%	3%	6%	12%
Thermometer	63%	32%	31%	42%

One would have expected the results for the identification of the test tube and beaker to have been much better than they were. All standard 5 teachers indicated that they had these pieces of equipment in their schools and 4 schools actually had enough for pupil use as well. Pupils commonly identified these items as 'jug' or 'container,' indicating that they are not familiar with what one might consider the simpler pieces of science equipment.

A particularly distressing result was that obtained in each class for the measurement of a single line segment. This was the only question that tested a practical skill i.e. the ability

to measure correctly using a ruler. The line was 6.5 cm long. The results seem to suggest that most pupils cannot measure a line segment correctly, and the few that can still experience problems with the different units of measurement. In cases where incorrect answers were filled in they were of 2 main types:

- a few answers indicated that the pupils had difficulty with the units of measurement and converting from millimetres to centimetres or vice versa. Answers in this group were measurements such as 65 cm, 650 cm, 0.65 cm;
- most of the incorrect answers were far from the 6.5 cm measurement e.g. 31cm, 130 cm, 10 cm. Some of these numbers were often so way off the mark that the researcher is of the opinion that in most cases these measurements were probably guessed rather than actually measured.

The non-response rates were fairly high for what was considered an easy exercise: 6A 30%, 6B 74% and 6C 53%. It would be easy to assume that all these pupils were incapable of measuring a simple line segment, but the reality of classroom dynamics for new standard 6 pupils raises other issues which should be borne in mind when interpreting these results. The researcher did not supply the pupils with rulers, and it is thus possible that many of the pupils did not possess rulers during the test or that the scales on the rulers could not be read. Pupils are not allowed to talk during tests and, being new to secondary school, may have lacked the confidence to ask the teacher to allow them to borrow a ruler from a fellow pupil. Many second language pupils do not have confidence so early in the year to make requests of the teacher out aloud in English, especially in front of their peers. The non response rate therefore, although high, does not allow one to differentiate between those pupils who could not measure the line

because they lacked the skill, and those who could not measure the line because they lacked proper equipment **and** the confidence to ask for help.

#### **4.3. ANALYSIS OF QUESTIONNAIRE ADMINISTERED TO SECONDARY SCHOOL TEACHERS AT RESEARCH SITE**

##### Questions 1 and 2.

Responses to these questions allowed the researcher to determine the teacher's science (general science, biology or physical science) teaching experience (in years). Judging from the number of years of teaching experience recorded, one would be able to conclude that the 5 teachers who completed the questionnaire are mostly experienced science teachers. The teacher with the least science teaching experience has taught general science for 4 years. The teacher with the most experience has taught science for 17 years. All teachers have taught standard 6 general science. One teacher had taught standard 6 general science for just one year (other 8 years teaching biology). All other teachers had been directly involved with standard 6's for more than 3 years. Two teachers had taught general science for more than 6 years.

##### Question 3.

This question asked teachers to list the skills they thought standard 6 pupils **ought to** possess on entry to secondary school. This implies that these skills ought to have been developed in the primary school. The list of skills supplied below was compiled, in descending order, starting with those skills most commonly listed by the teachers.

Teachers were not asked to order their list of skills in terms of those they thought more important and those they thought less important.

- Measurement skills (including reading from apparatus). This was placed at the top of 4 teachers' lists.
- Recording of information .
- Ability to observe carefully.
- Ability to make comparisons.
- Identification and manipulation of equipment.
- 'Mathematical skills'- manipulation of numbers in calculations, tables and graphs.
- Make accurate drawings from observations.
- Draw conclusions from experiments.
- Communication skills, including listening.
- Follow instructions carefully.

The teachers were also asked what skills they thought the pupils DO possess on entry to secondary school. The striking feature about the response to this question was how little information was recorded, when compared to the previous question. One teacher left this question completely blank. Others filled in one or two items such as:

- Some can measure accurately (3 out of 5 teachers);
- Some can record information (2 out of 5 teachers).

The last part of this question asked teachers what skills they thought were ABSENT in science pupils who came to secondary school. Because so few skills were perceived by the teachers to be present in the pupils, most of the skills that were listed as ' OUGHT TO' became the same skills that were stated to be absent. No new items (i.e. not found



in the skills already listed) were recorded, except for one: “pupils cannot keep quiet and listen”. This response seems to point to a more traditional, authoritarian teacher-pupil relationship, with a view of the learner as a passive recipient of knowledge.

Question 6 asked teachers what they thought their standard 6 pupils should be able to do by the time they have completed standard 6. 4 of the 5 teachers mentioned that skills that they ought to have possessed on entry to secondary school should now be fully developed. Two teachers felt that pupils should be able to make logical deductions. This was not specifically mentioned as a skill they ought to possess on entry to standard 6. Two teachers felt that the pupils should display the ability to transfer knowledge gained e.g. “.....pupils should be able to use subject matter in new situations.....pupils should be able to transfer classroom learning to their own environment.” One teacher mentioned that pupils should have developed confidence “to ask and answer questions”. It is clear that within a single school science department, the teachers seem to have different expectations of their pupils at this stage.

It is evident then that teachers have expectations of pupils on arrival to the standard 6 science classroom. They were able to fill in much more information when asked what pupils **ought to** be able to do and what pupils **cannot do** than when asked what pupils **can** actually do. This seems to suggest that their expectations are not met and they display very little confidence in the preparation of these pupils in the primary school. Since many skills are found wanting in these pupils on entry to standard 6, teachers are suggesting (albeit subconsciously) that these skills will have to be developed and /or refined in standard 6. Oral discussion with teachers (page 108) in this regard raises some

interesting discrepancies between what teachers think their pupils should be able to do, and what they think they (the teachers) are doing to bring this about.

Since this research recognised that the majority of standard 6 pupils are learning science in their second language, questions 4 and 5 related to the teaching of science for second language pupils. Question 4 asked teachers to discuss any difficulties (apart from fluency in English) they encountered with teaching science to English second language pupils.

The response of 3 teachers related to the lack of skills already discussed in the first part of this questionnaire. They seem to highlight the poor primary school experience as the major factor...”pupils have mainly learnt science through textbook and blackboard summaries.....lack of exposure to science resources.....emphasis on rote learning”. Two teachers emphasised the pupil’s role in the classroom context rather than the absence of skills. Both teachers mentioned “..reluctance to ask and answer questions..... too accepting and unquestioning”.

Question 5 asked teachers to state any changes that they had made in order to accommodate the second language science pupils. Responses seem to indicate that the amount of subject matter now taught is less than that actually required by the official syllabus: “...cut down on the contents of the syllabus”. 3 teachers related the change to the pace of teaching in the classroom: “slower pace” and “slower rate” are the words used. Teachers also feel that they now place much more emphasis on the use of practical demonstrations, and various visual aids to overcome the language barrier ”...almost a return to the kindergarten approach”. This is accompanied by more emphasis on appropriate examples from the context of the pupils lives. Three teachers used the terms

“simplified language” and or “simplified most of the content matter..... demand level of work is now lower” to convey change. Only one teacher mentioned trying to emphasise the skills as a means of bypassing the burden of rote learned foreign facts.

In this situation then, it seems that one might be inclined to question whether teaching ‘less’, or ‘slower’ and or ‘simplified’ content (as suggested by the teachers) are actually changes which successfully meet the learning needs of the second language pupils. Tobin and McRobbie (1996) make an important point when they draw attention to the fact that although some teachers were sincere in their efforts to provide assistance to students with limited English proficiency, “they made their efforts within a culture that assumes that the curriculum will be enacted in English and that the standards of ethical practice also will be judged within a hegemony that is centred on the use of English” (p.280). Other components of this hegemonic platform were beliefs that made sense of teaching and learning in terms of the transmission of knowledge from a teacher regarded as the principal knowledge resource, a necessity to employ efficient teaching and learning practices, a desire to maintain rigour in the enacted curriculum, a perception of time as a precious commodity that was scarce and finite and a need to prepare students for success in examinations and tests (Tobin and Mc Robbie 1996, p.280). Many of these components have been highlighted in the analysis of teacher questionnaires and in discussion with teachers at the research school, and the challenge then is to initiate change and to evaluate progress within a variety of frames of reference.

#### **4.4. ANALYSIS OF GROUP DISCUSSION WITH SCIENCE TEACHERS AT THE RESEARCH SITE**

Teachers were shown histograms depicting the performance of the standard 6 pupils in the category 'reading information' (see p.79). They were also supplied with a copy of the test questions used in the assessment of some science skills of these pupils.

##### Any comment on the results?

The teachers were generally surprised by the poor results because "the questions look so simple, the kind we could easily use ourselves". They felt that both questions were within the range of potential for standard 6 pupils and that pupils should have gained experience with these two question types in their primary school science and / or mathematics. Standard 6 teachers admitted to using tables very early in the year with this particular group of pupils. They did not specifically teach how to read a table i.e. locate points, move down or across etc. before supplying the simple table. After marking pupils' work they found that the main problem was the inability to use the table format correctly rather than difficulty with understanding of the subject matter.

##### Did you expect the results on the Zulu test to show an improvement over those taken in English, by the same group of pupils?

Overwhelming agreement by teachers. All expected the pupils to perform much better on the Zulu test. There was the feeling that the results should have shown a much more significant improvement than actually recorded. Since the focus of many lessons is on language and comprehension any factor which aided this should have produced better results. These expectations were related to their classroom experience. Teachers related

several instances where they have used one pupil to explain a concept, in Zulu, to the rest of the class. According to one teacher “the change in facial expression is almost immediate”, indicating an understanding achieved through the use of the mother tongue. A teacher raised the point that since the results were generally low for all students writing in their mother tongue (English and Zulu), this indicated that the ability to read information presented was not well developed “...this means that we will have to concentrate on teaching the skills **and** developing the language, rather than always focusing on the language”. This was an important point and led to the next question.

Are you emphasising the acquisition of skills in your classroom teaching?

At this point there was a brief silence. The silence was not uncomfortable, but the researcher was inclined to think that because she was part of the teaching team, teachers were aware of her experience of the teaching context in the school. The teachers, functioning in this instance as a science department, were involved in an exercise of self-reflection and their thoughtful replies showed this.

The answers were at first hesitant “...we’re trying to..... I don’t think so..” without anyone qualifying each statement. Finally a teacher said that she felt that she was not emphasising the development of skills in her science teaching in the present context. She went on to explain that she spent so much time just making sure that the second language pupils understood what she was saying “... most of the time I don’t consciously think about the particular skill involved - I’m so caught up with trying to make them understand what it is I am saying.” Other teachers seemed to agree that the language and comprehension factor was often an overriding concern.

Another point raised by the teachers was the fact that they mistakenly took so many things for granted when planning lessons and allocating time for completion of work i.e. they assumed certain skills have already been developed in the pupils. They don't realise which skills are absent until they are busy teaching something where understanding is dependent on a previously learnt skill. A teacher used an experience to illustrate this point. While teaching density, the teacher called one of the pupils to measure the length of a block of wood. The pupil, although supplied with a ruler, was not able to provide the correct measurement. A second pupil was able to measure the length correctly and this pupil then showed the first pupil how to measure correctly. The teacher then continued with the lesson. But the teacher then raised a point about his personal dilemma at this time in the lesson "...what about all the other pupils in the class who may not know how to measure a line - if I stopped the lesson to teach them how to measure a line, then I would surely never get to finish this section on density". Another point raised in this regard was important "... in the written exams they have to know how to calculate the density using the formula...the measurements will be supplied to them". The implication is that it is more important to know how to calculate the density of an object using some formula than to know how to measure the length of the object. The pressure to 'finish' a section of work in an allocated time period is also evident in the remarks made.

#### What hinders the teaching of skills in the science classroom?

Many of the points raised by teachers related directly to the teachers themselves, rather than to the pupils. The main points are summarised below.

- Teachers with quite a few years teaching experience have almost become 'comfortable' in their teaching role and with the same subject matter which has been used over and over again.
- The type of teacher training received by many of the teachers hardly ever placed emphasis on the development of skills. A teacher recalled that most attention was always placed on the strictly detailed lesson plans from which one was seldom encouraged to deviate.
- The enormous pressure of planning and preparing for lessons with classes that are so varied in their primary science experience is also a challenge. This requires a great deal of time and effort outside the lesson itself.
- Concerns in science practice are usually centred around administrative tasks such as 'who sets what paper' instead of proper long term planning by teachers as a group. Once again, this type of group planning and development requires additional time and commitment.
- The concentration on content and the need to 'complete' the loaded syllabus in a specific time period each year is still a major concern.

What do we need (to do?) to bring about the necessary changes?

Points raised in answer to this question seem to fall into 2 different categories:

1. Those suggestions which pertain to the teachers in the research site and what they think they must do to bring about change in their context.
2. Those suggestions which pertain to areas outside the research site and beyond the control of the teachers, but which can influence change.

Teachers felt that it was vital to create an increased awareness of skills amongst themselves. They felt that their knowledge of necessary skills and how best to develop them in the pupils had to be reassessed. This necessitated more communication between teachers of different standards. Teachers could no longer function in isolated units as common skills had to be identified and developed as pupils progressed from one standard to the next.

As regards the second category of suggestions, the first point raised was in relation to the fact that "it is so late to start teaching skills in standard 6". Teachers felt that a stronger foundation was needed in the primary school than was being provided at present. Teachers also felt that many of them wanted "retraining", to be exposed to new ideas so as to create a wider vision. The general feeling was that the education department was not doing enough in this regard. Most teachers spoke of a sense of frustration, created chiefly by the gap between changes often suggested by education officials and the reality of the classroom situation.

Through the responses in the discussion one is able to conclude that the teachers involved felt that the onus for positive change was definitely on the teachers themselves. The general feeling was that they did not always emphasise skills teaching and that much of the focus is still on the traditional transmission of facts. Through this discussion, an initial awareness of skills based teaching was explored, and provided the groundwork for further meetings in this regard.



#### **4.5. ANALYSIS OF QUESTIONNAIRE FOR STANDARD 5 TEACHERS IN FEEDER PRIMARY SCHOOLS**

The overall response rate for this group was very poor, despite numerous follow-up attempts by the teacher. New forms were sent to schools when a form was indicated as lost. Some teachers accepted the forms and said that they would post them, once completed, to the researcher. These responses were not received in the post. Ten completed forms have thus been analysed. Four questionnaires were from teachers in ex-H.O.R. schools and 6 questionnaires from teachers in former black schools. This is not a representative sample of all the feeder primary schools of the standard 6 pupils and results cannot therefore be generalised to the entire sample. The questionnaires received have been analysed because it is felt that they will still convey information about the primary science experience of some pupils.

##### **4.5.1. TEACHER BACKGROUND**

All 10 teachers have a professional teaching qualification. 8 teachers have more than 8 years experience in science teaching, with 2 teachers having only taught general science for a year. The sample included 7 male teachers and 3 female teachers.

##### **4.5.2. SCIENCE "ENVIRONMENT"**

Each standard 5 class seems to be allocated at least 6 general science periods per week or cycle, with only 2 teachers recording 5 periods per week. Teachers generally teach an

average of 2 different science classes (e.g. 5A, 5B) per week. It would seem then that in these schools an officially acceptable amount of time has been formally allocated to general science teaching in standard 5.

The situation appears varied with regard to pupil numbers in each class. 4 teachers have between 30 - 35 pupils per class. 4 teachers have between 40 - 43 pupils per class. 2 teachers however reported class numbers of 48 and 56 pupils. These numbers are above the recommended pupil teacher ratios and are not conducive to effective learning. It is not surprising therefore that these two teachers indicated that their pupils have to share textbooks, 3 per book in the case of the teacher with 56 pupils per class.

#### **4.5.3. EQUIPMENT**

All 10 schools indicated that they did not have a laboratory in their schools. However all schools have at least some of the equipment on the list provided, with 2 schools having all the items listed. 6 schools recorded less than 2 items unavailable in their schools. In many cases this equipment is enough for demonstration use only. All schools indicated that they possessed test tubes, with 4 schools having enough test tubes for groupwork by pupils. Beakers were common to all schools except one, though only enough for demonstration purposes. As to be expected, the microscope was only found in 4 schools, with 3 schools indicating that they did not have mass meters.

These results appear to reflect rather favourably on the presence of science equipment in the primary science classroom. This might be misleading since literature indicates that in

many regions in South Africa “there is an acute shortage of apparatus and materials for the demonstration of experiments” (Chacko 1995, p.73). In no way do the results reflect whether these items are actually used, by teachers and or pupils, in daily teaching practice. Pupils however had difficulty identifying test tubes, beakers, measuring cylinders, thermometers and microscopes when pictures of these were presented to them in the content assessment test administered in January 1996. Hence the results seem to suggest a discrepancy between the equipment (needed in standard 5) that is actually available in the schools and the ability of the pupils to identify this equipment. The small size of the sample analysed prevents more definite statements in this regard.

#### **4.5.4. LANGUAGE POLICY FOR SCIENCE TEACHING**

5 teachers indicated that they used only English for all aspects of classroom instruction listed in the questionnaire. One teacher in this group made contact with the researcher to ensure that his language policy was clearly understood. As an English speaking teacher in an English medium school, he used English for classroom instruction. However when he perceived that pupils were having difficulty understanding concepts, he made use of Zulu-speaking pupils to explain the concept to others in Zulu. This policy seemed to be in keeping with what standard 6 science teachers at the research site found to be effective as well (see page 108). All other teachers used only English for notes and worksheets and tests. However, when explaining concepts, doing remedial work or engaging in informal discussion with the pupils, they used mainly English with some Zulu.

#### **4.5.5. CONTENT COVERED IN STANDARD 5**

The standard 5 teachers seem to be able to cover almost all the topics specified within the formal syllabus. The only two areas which seemed to be left out by some teachers were Algae (5 teachers) and Sorting and Classifying (4 teachers). All teachers indicated that they had covered the section on the Pine and yet many pupils were not able to identify the pine cone and or pine tree in the content assessment. Possible suggestions for this situation were put forward on page 98.

#### **4.5.6. PROJECTED SKILLS OF PUPILS BY THE END OF STANDARD 5**

One teacher did not respond to this section as this was his first year teaching standard 5 general science. Hence only 9 questionnaires were analysed for this particular section. The number of teachers and their predicted percentage of pupils able to successfully complete each task at the end of standard 5 is recorded in the table below.

Table 6. Number of standard 5 teachers giving certain predictions for pupil performance on each task by the end of standard 5.

Number of teachers giving each prediction.

Task	No response	More than 50% of pupils	About 25% to 50%	10% or less pupils
Make a clear diagram from a specimen supplied		6	2	1
Measure(in mm) a straight line.		5	4	0
Calculate the area of a square or rectangle		6	3	0
Tabulate differences between objects	1	5	3	0
Plot points on a graph	3	2	4	0
Make predictions from data supplied	1	2	3	3
Recognise the order in which a sequence of events takes place.		4	5	0
Write up the results of an experiment		3	4	2

The teachers seem to be fairly confident that more than 50% of their pupils are able to measure line segments. This measurement is also necessary for the calculation of area, a task 6 teachers think possible for more than 50% of standard 5 pupils. Once again, these teacher predictions did not match pupil performance on the assigned measurement task. Teachers were not very confident about pupils' ability to make predictions and with good reason as the results indicated very poor performance in this area. It is possible that teachers recognise that pupils have not been exposed to this type of exercise through their (the teacher's) teaching, and hence the lack of confidence in pupil ability to make predictions.

The non-responses are surprising, since the categories provided allow for even very small numbers of pupils with the ability to carry out a particular task. If one tries to look for reasons why a non-response or low percentage prediction would be indicated for a particular task, then the following are possibilities:

- a) The teachers are aware of the fact that they have not performed these tasks with pupils in their science classroom and hence cannot make accurate predictions about pupil performance in that regard.
- b) The teachers have performed these tasks with their pupils but feel that the 'fault' lies with the pupils e.g. pupils are considered 'weak' and hence not able to successfully complete the specified tasks.

This research would not be able to provide a definite conclusion in this regard from the questionnaire responses analysed. Further discussion would be needed with the teachers.

## **CHAPTER 5**

### **SUMMARY, CRITIQUE, RECOMMENDATIONS AND CONCLUSION**

#### **5.1. SUMMARY OF FINDINGS**

This discussion hopes to draw together some of the key features and findings so that an overall picture might emerge for this research project.

The complexities of working in secondary multilingual science classrooms are not unknown, and Jill Adler (1995) draws attention to the dynamic interplay between the various factors. These are quoted as “...the pedagogical approach (the way in which knowledge is transmitted, received, taught and learnt), the demands it makes on the pupils communicative competence (narrow focus on their ability to speak in ways expected), the classroom’s multilingual character (the extent to which pupils share spoken language and language of instruction) and the canonised school knowledge (content, skills and processes in the curriculum).” The researcher has found this dynamic interplay to be important, so that one can hardly investigate one area (in this case school knowledge) without several other factors being brought into play (in this case language and pedagogy). For this analysis then, test results were interpreted in the light of teacher’s responses to questionnaires, group discussion with teachers and the knowledge of the classroom context afforded the researcher in her role as practitioner and researcher.

With regard to the assessment of certain science skills, the results seem to indicate that the skills tested are generally poorly developed within the standard 6 pupils tested. If one

examines the mean score for each question, as well as the mean score for each category, one can see that the outcome is fairly dismal. One might ask what an 'acceptable' score might actually be? The answer can never be a simple figure arbitrarily chosen as a cut-off point, because "whether or not the level of performance on a sub-category is taken to reflect a satisfactory state of affairs is a matter of judgement" (APU 1982, p.198). It is possible that the expectations of different people making this judgement may vary. Few would suppose that children would succeed 100% on all questions and few would be satisfied with a low level of scoring throughout. As suggested by the APU report of the 1981 survey, "it is important therefore that any judgement about whether or not performance levels are thought to be high enough is made with reference to the questions and the mark schemes which were used" (p193).

Results obtained for the pupils tested in this research suggest that pupils were able to perform better when required to:

- Read information presented in the form of a table.
- Place pictorial information supplied in the correct sequence of events.

Both of these skills might be regarded as general skills important across the curriculum, and should most certainly be encouraged in subjects like geography, history and the languages. The 'general' approach to a problem, whether in practice or on paper, is characterised by a relevant start followed through by the use of qualitative and intuitive methods (APU 1982, p.294).

The mean scores for all the standard 6's in every other question in the test is less than 20%, and in many cases less than 10%. These mean scores are particularly low, even

when one takes into account certain specific factors raised in discussion of questions in chapter 4. This suggests then, that at the research school, very few standard 6 general science pupils, of average age 15.2 years, were able to do the following.

- Add information to a partially completed graph or chart.
- Apply science concepts to explain results.
- Use the given information to make reasonable predictions.
- Suggest controls in planning parts of investigations.

This conclusion is in agreement with that of the APU assessments where "... overall results seem to suggest that children are much more confident in their use of general skills across the curriculum, but less confident in skills more specifically related to science, such as defining patterns in observations, explaining, predicting, hypothesising, controlling variables and planning investigations" (Raper and Stringer 1987, p.9). In all cases this is probably due to the reduced opportunities to develop these skills in the classroom. McDonald (1990) talks about maintenance learning, where there is the acquisition of fixed outlooks, methods, rules for dealing with known and recurring situations. 'This kind of learning enhances our problem-solving ability for problems that are given' (p4). Assumptions are never questioned and new perspectives seldom sought. Results suggest that pupils have most probably been engaged in maintenance learning (as opposed to innovative learning) for most, if not all of their formal primary schooling. Questions were regarded as 'funny' because they did not relate to the format and content pupils were accustomed to.

The questions used in the skills test were taken from a sample of questions used by the APU to test science performance of 11 year olds in the United Kingdom. The average



age of the pupils in the present research sample was 15.2 years. The estimated mean performance estimates for 11 year olds in each of England, Wales and Northern Ireland can be found in Appendix 9. The 11 year old APU pupil sample seemed to perform better at representing information as graphs, tables and charts than in reading information from tables graphs and charts. The converse seems to be true for the research sample, with the pupil performance in reading information much better than that for adding or representing information in the form of tables, graphs and charts. Another difference between the samples relates to the performance in interpretation of presented data and application of science concepts. The APU sample performed better at interpreting presented information than they did in applying science concepts. Once again the converse is true for the performance of the research sample, perhaps because of the influence of the 'frog' question scores. In all skills categories tested the mean scores (estimated percentages) achieved by the 11 year olds are far greater than that achieved by the research sample, even if one considers performance in mother tongue. The size of the present research sample and the limited number of each type of question used in this research assessment does not allow the researcher to make definite statements with regards to these patterns in pupil performance. More investigations using a variety of South African pupil populations are needed to further explore the existing data.

It is interesting to note that the secondary teachers who completed the questionnaire did not list any of the aforementioned skills (defining patterns, controlling variables, predicting hypothesising etc.) when asked what skills they thought pupils ought to have. One also found that the primary school teachers, when supplied with a list of skills, predicted that they thought very low percentages of their pupils would handle tasks more

specifically related to the science skills e.g. make predictions. Secondary school teachers' lists indicated an emphasis upon measurement skills, recording of information and observation skills. The primary school teachers also predicted that more than half of the pupils would be able to measure correctly and perform calculations that relied on measurement. The stress on measurement and observation was raised again in the group discussion with secondary school teachers. This seems to suggest that many of the teachers are operating within the realms of the more traditional view of science, with emphasis on aspects of objectivity and reliance on the senses for information. One of the first lessons learned by all beginning science students is that observation is the basis of the scientific method. This is related to a positivist emphasis on 'neutral,' scientific facts. This focus is dangerously narrow in view, especially when compared to the science and technology abilities envisaged in a student who has successfully completed the GEC (page 5).

Since the science teachers in general, and the standard 6 science teachers in particular, admit that they have not yet successfully developed teaching patterns which emphasise the understanding of subject content **and** skills (rather than content only), one wonders what skills these pupils might possess if they leave the formal schooling system at the end of grade 9 next year.

The content assessment related mostly to work that pupils should have learnt and understood in standard 5 science. The results suggest that even though many of the topics may have been taught, almost half of the pupils in each class analysed held common misconceptions about more general science concepts e.g. 'living and non-living'

and 'energy'. These misconceptions were not unlike those found in other primary school children tested by the APU (Driver et al. 1994). Research has shown that alternative conceptions cut across age, ability, gender and cultural boundaries (Wandersee, Mintezes and Noval, 1994, in Rosenthal, 1996, p17).

It was also in this type of content based assessment that the most variation in results was obtained between classes. As pointed out in chapter 4, 6A consisted of mostly English first language pupils from a local feeder primary school who probably shared a comparatively resource -rich primary science experience. For 6B and 6C the results could be explained in terms of primary science experience and language of presentation of the test. Many of the pupils in these 2 classes come from historically black urban and rural schools with varied opportunities for the development of primary science. The research showed discrepancies between the content standard 5 teachers indicated they had taught and the equipment the schools possessed, and the ability of the pupils to explain certain science concepts and recognise the equipment in standard 6. A larger sample of standard 5 teacher questionnaires would have enabled the researcher to highlight the primary science environment more clearly. Secondly, the test questions were presented in English, and the pupils had to respond in English as well. The researcher felt that the content assessment questions dealt mostly with specific general science-related terminology which would most probably have been used in a primary science classroom which used a language policy of English and Zulu for explanation of concepts. However, one cannot ignore the fact that the pressure of their first English science test, without the help of Zulu informal discussion to elucidate, probably affected the performance of many pupils in these classes. In the skills assessment, second language students did perform

better in the explanation of science concepts when these were presented in the mother tongue.

This variation in content assessment highlights possible 'damaging' teaching practices if a school creates classes where students are equally proficient in one language (in this case also the medium of instruction in the school) and who also share a similar cultural background. This description fits 6A, and teaching and assessment which stressed knowing and regurgitating the facts of the subject matter would probably reveal 'good' grades for this type of class. 6B and 6C are more culturally and linguistically diverse, without a shared primary science experience, except maybe in the sense that it was mostly carried out in a very disadvantaged educational system. Lacking both the necessary content and the language proficiency, in the traditional classroom that emphasises memorisation of facts, they would possibly always achieve 'lower' grades. However, one notices that **all** students performed poorly on most categories of the skills assessment, in spite of the use of the mother tongue. This kind of information would hardly ever become evident where assessment and teaching failed to test and develop general and scientific skills. Hence teachers might be inclined to approach classes in terms of one class being "better" (academically) than another when in fact the reality is that **all** pupils are in need of development of various skills.

Achievement in science depends very much on a combination of language proficiency and cognitive and memory skills. The analysis of the secondary teacher's questionnaires and the group discussion held with teachers, highlight the fact that language (or more specifically the English language) is a major issue in the teaching of science. One might

be tempted to say that, in most instances, the sometimes central focus on English language and comprehension has resulted in the neglect of the development of skills needed.

Samunda (1986, in Doran et. al 1994, p.567) discussed technical, structural and scientific racism as they relate to assessment. He found, amongst others, the following underlying assumptions of some test makers:

- there is a commonality of experience shared by test takers;
- every test taker has equal facility with the language used in class instruction;
- the syntax and word usage are familiar to all test takers and sociocultural, economic and linguistic differences can be ignored.

None of these underlying assumptions is valid in the research school and all were especially relevant to bear in mind in the standard 6 group assessed. Hence the researcher felt it necessary that in order to test the skills, rather than the pupils' language competency, the pupils should have the opportunity to write the test in their mother tongue. The results show that the performance of pupils increased when pupils were presented with a test in their mother tongue. A study of the mean scores of each question and category points to the fact that all questions, except number 12, showed an improvement (sometimes very slight) when the test was taken in Zulu. Both English and Zulu pupils performed well on the same set of questions (questions 2 and 5) when tests were taken in their respective mother tongues. The fact that none of the scores were high for both English and Zulu tests for questions relating to interpreting, planning and adding information, indicates that these skills are either not known or not understood, rather than an issue of linguistic difficulty. These findings correspond with the work of Cecelia

Sentson (1994) as reported in chapter 2. The improved performance with the use of the mother tongue is an important factor for teachers to become aware of, especially since the medium of instruction in the school is English. As pointed out by Rosenthal (1996), "it also indicates that poor test grades, ungrammatically written assignments and little participation in class discussions do not necessarily mean that ESL students are dumb, lazy or not studying; rather, these students may still be developing cognitive/academic language proficiency in English. In fact, when it comes to their academic coursework, many may be trying just as hard or harder to succeed than their native English speaking classmates even though their efforts may not manifest themselves in terms of achieving 'good' grades" (pg 49).

The Zulu pupils found this task of providing more detailed, written science explanations in Zulu, to be more difficult than they first thought. It is possible that they have not developed their mother tongue to a level of using it to provide more formal scientific discussions. This was reinforced by the translators who remarked that the Zulu (words, grammar etc.) used "was not very good". This has implications for these pupils if one regards the Dawes-Cummins threshold hypothesis that: "when the learner has a low level of proficiency in both L1 and L2, this type of bilingualism (semi-lingualism) has negative cognitive effects on the learning process" (Sentson 1994, p.111). The student who has poor native language skills and little formal education in L1 will have a much harder time developing cognitive/academic language proficiency (CALP). And as mentioned previously, Cummins states that it is CALP that will determine an individual's success in school (Rosenthal 1996, p.50).

The standard 5 and 6 teachers seem to be using a mixed language policy in their classrooms, but with slightly different emphasis. An analysis of the primary teacher's questionnaires revealed that many standard 5 science teachers in historically black schools used English and Zulu when (a) explaining concepts and (b) for informal classroom discussion. In these situations mother tongue is used to facilitate learning and to facilitate teacher-student rapport. For the standard 6 teachers the situation is somewhat different. Clearly a mixed language policy is not feasible for a teacher who has no proficiency in the mother tongue of the pupil being taught. Hence the need for these teachers to use other pupils as a means of facilitating the student-teacher communication. This policy appears to "contain not only a 'message-getting-across' strategy, but also time saving strategies" (Harbord 1992, p.352). This was probably related to a teacher's remark in the group discussion "...everything takes so long these days...you have to explain and explain and explain..." Nangu however warns that the mother tongue "should be used to provoke discussion and speculation, to develop clarity and flexibility of thinking and to help us to increase our own and our students' awareness of the inevitable interaction between the mother tongue and the target language that occurs during any type of language acquisition" (Nangu 1994, p.292).

From the comments made thus far, it may seem rather unusual to be discussing issues from such different fields of study as science and second language acquisition. However, the two merge when we consider the educational needs of students of limited English proficiency. It is important then, that any plans to reform science education in the present multilingual classroom must address both the educational and linguistic needs of the rapidly growing population of pupils with limited English proficiency.

## **5.2. CRITIQUE: LIMITATIONS AND STRENGTHS OF THE RESEARCH**

Criticism might be levelled at the interpretation of results obtained from the form of pen and paper test used in this research project. According to Black (1990, p25), "Short tests of pupil's performance, limited to only 1 or 2 questions for any one criterion, cannot give a reliable result, even for a large group, let alone for one individual child". The researcher is aware of this particular limitation, but is of the view that the results, when interpreted in conjunction with primary and secondary teachers involved with the children, are fairly reliable in the context of the research group. The researcher does however acknowledge that the results are not conclusive, mainly because a narrow range of methods in assessment can give an unreliable picture of pupils' capabilities. In this case, skills assessment occurred via an external, written test. It is just as clear that "measuring some skills in a 'practical' situation would produce different results than assessing those same skills in a paper and pencil situation" (Doran et.al. 1994, p.418). This point is illustrated by the work of the APU itself where it was found that "pupils performed well in handling information in tabular form in the written test, though they rarely used tables to organise the data in their own investigations" (APU 1984, p.282). The results of the APU assessment suggested then that the performance of the skills (categories 1 to 5) was very dependent on the content and context of the assessment situations. Practical testing is by nature logistically complex and the researcher was unable to co-ordinate this amongst the classes used in this research. The implementation of practical testing on a larger scale, as validated by the APU, would definitely add a further dimension to the interpretation of results. One might be excused in this instance since the results were not to be used to determine important decisions about individual



pupils' futures, but rather as a diagnostic tool to recognise previous learning and help to build on the experience people bring to learning.

The dual role of the researcher as 'colleague' who was directly involved with the realities of science teaching at the research school, and that of 'student' who needed to collect information for an academic purpose i.e. obtain a degree, was not always clear. The science teachers involved were very co-operative and the research did lead to much needed discussions about current teaching practice, especially with regard to skills development. However, the researcher is concerned that the momentum achieved will be dissipated if teachers linked the discussions chiefly to 'the project' of their colleague, rather than genuinely internalised the policy for change. The researcher feels that to avoid this 'lack of ownership' complex developing, it is important that all teachers feel able to exercise control and ownership of the changes needed, and accept joint responsibility for these and the outcomes.

The very low response rate of the questionnaires administered to the primary school teachers was also a limiting factor of the research. A higher response rate would most probably have revealed a more complete scenario of the extent of the differences in the pupils' formal primary science experience. As discussed earlier, discrepancies exist between what these teachers say they manage to teach and what equipment they have available in their science classes, and pupil performance on entry to secondary school.

This assessment had an unintended positive effect for the researcher in the classroom context. Pupils were genuinely surprised to be able to take a test in their mother tongue.

In secondary school most of their energies seemed to be spent focusing on the development of English, so that a test where one was allowed to answer in Zulu was certainly a novelty. The researcher went on to explain, to the pupils she taught, the reason for the use of the mother tongue in the assessment. This open articulation and discussion of issues of language in the science lesson seemed to have had a significant impact on the pupil-teacher relationship and especially on pupil confidence to speak out aloud in the classroom. It was as though linguistic differences were openly, and more importantly, positively recognised and pupils felt that their mother tongue had received 'formal' recognition in a situation where the teacher was not compelled to do so. Showing practical awareness of a difficulty became an unforeseen way of developing rapport. The researcher did not foresee this effect, but remains mindful of and grateful for the personal lessons learnt in this situation.

### **5.3. SUGGESTIONS FOR FUTURE RESEARCH**

On examination of the findings of the skills assessment section of this research, the first question that came to the mind of the researcher was "what difference would there be in performance if this test was taken by standard 6 pupils in other schools?" Further testing of pupils from different primary school backgrounds might give an indication of the role of school variables in pupil performance. It could afford science educators insights into the level of skills development in pupils on entry to secondary school. Further testing should involve more discussion with pupils to develop a deeper understanding of their science concepts, especially in light of the findings of McDonald (1990) viz. "There was

the finding that the children were able to deal better with higher order concepts orally rather than in the written form”.

An integrated approach to education implies a view of learning which rejects a rigid division between, amongst others, ‘knowledge’ and ‘skills’. As the new education dispensation in South Africa heralds a move towards a skills-based approach, the challenge lies in first identifying teachers’ understanding of this concept. What is their understanding of the concept of skills? Are teachers, even within the same school, unanimous in their understanding of what counts as a skill? Any serious misunderstandings or alternative frameworks held by teachers will surely affect the implementation of any skills based innovation.

“Change in education does not come about by acting on people and for that matter researching them or their actions. The people concerned need to become an integral part of the research and decision making” (McNaught and Raubenheimer 1991, p.2). This is especially relevant in the context of this research project. Any future research within this setting must of necessity involve the teachers and their ideas on how best to bring about innovative science teaching within the reality of their situation. It is imperative that teachers be afforded a creative role in any new initiative. To maintain these changes in a system which encourages conformity requires consistent support for the practitioner.

In the multilingual classroom facing most teachers today the greatest challenge lies in being able to shift their traditional pedagogy and create more language rich classrooms. This is often thought to be more difficult for science teachers who may have no formal

skills related to language teaching with which to do that. In what ways have science teachers modified how they teach to better meet the needs of students who are learning science through an unfamiliar language? This research has reported teacher strategies such as ‘talking slower and emphasis on more visual aids’. These are indeed helpful changes, but are there more innovative, feasible ways of teaching science so that English does not become an insurmountable barrier? Much research in science education in South Africa today should address both the linguistic and educational issues raised by questions like those above?

#### **5.4. CONCLUSION**

The results reported in this research provide strong evidence that science education in both primary and secondary schools is probably primarily structured around the acquisition of knowledge, the content or subject matter. As results show, even this knowledge of facts is at best shaky, especially when it does not fit within the familiar routines within which it was developed. The acquisition of this knowledge is also hampered when pupils receive instruction in a language that is not their mother tongue. Most educators would agree that skills (conceptual understanding, thinking skills, practical skills, reasoning skills, reflection skills and problem solving skills) are at least as important as the specific content, yet rarely are they actually taught, and even more rarely included explicitly as part of a syllabus or assessment tasks..

A suggestion offered by Diane Grayson (1995, p.57) is one that science educators ought to heed:

“If we combine the teaching of knowledge with the teaching of the sorts of skills mentioned, then we will help to develop students who have not only knowledge but also understanding. Such students will be in a strong position to be fully participating, contributing members of a democratic society.”

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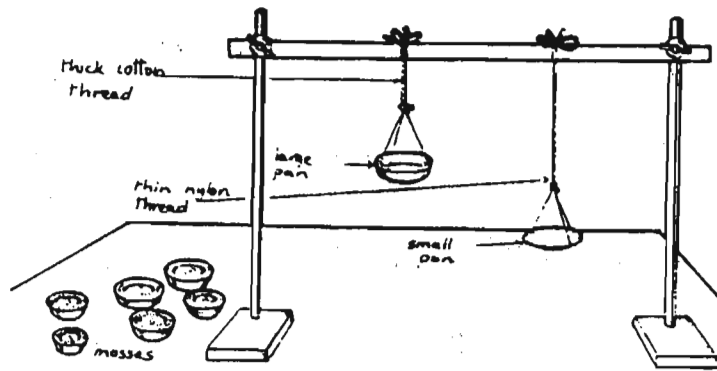
**APPENDIX 1.**

**SKILLS ASSESSMENT USING APU QUESTIONS - ENGLISH TEST.**

### Question 11

David and Pritpal were finding out whether nylon thread is stronger than cotton thread.

This is what they did :



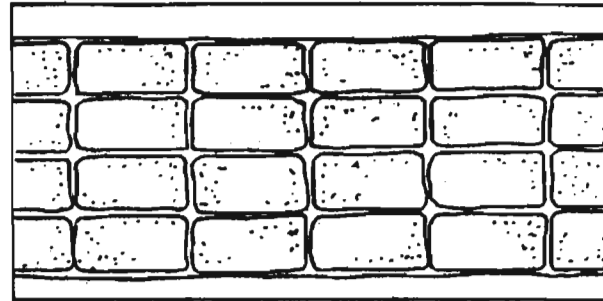
They put masses in the pans and found out how much mass was needed to break each thread.

This is not a very fair test. (max 3)

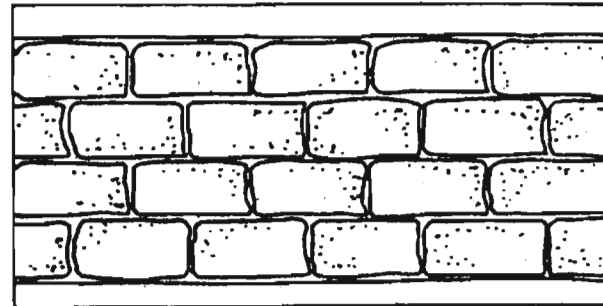
Write down three changes that would make it a more fair test.

1. Have 2 threads same thickness
2. Have 2 threads the same length
3. Pans the same (mass, weight, size)

Tim built a 'wall' using boxes as bricks, like this:



Flo built her wall from the same kind of boxes, like this:



They wanted to see which wall was the stronger. They decided to do this by rolling balls along the floor to hit the walls. To make this a fair test they must keep some things the same for both walls.

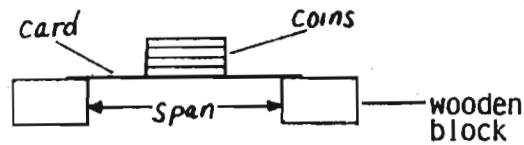
Write down 3 things that you think should be kept the same:

1. Roll the balls from the same distance away from the walls/ with same force/ same no. of balls used/ hit wall in same position/ same balls/ weight/ size of ball.
  2. Walls - same height/ no. of boxes/ height of boxes.
  3. - boxes same distance apart/ - same thickness of wall.
- (max 3)



# Question 9

Julian made a model bridge out of two blocks of wood and a piece of card.



He measured the span in cm and counted the number of 2c coins the bridge could support. Here are his results:

Span in cm	Number of 2c coins
10	5
18	1
12	4
16	2
14	3

a) What pattern do you notice between the span and the number of 2c coins the bridge could support?

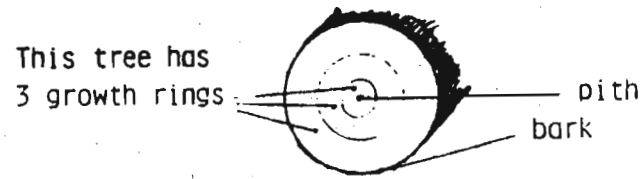
(3) The pattern I notice is each time span increases by 2cm the bridge can support 1 2c less (quantitative)

or (2) The wider the span, the less the bridge can support (qualitative)  
or - statements about some of the data (max 1)

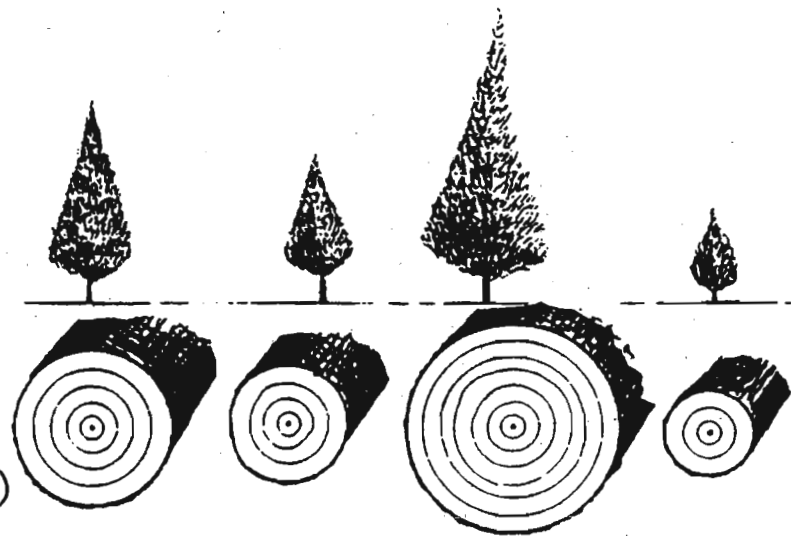
b) How many 2c coins do you think the bridge would support when the span is 8 cm?

I think that the bridge would support 6 <sup>✓(1)</sup> 2c coins.

10.



The trees below were planted at different times in the same wood. The drawings show the trees before they were cut down and underneath, the growth rings seen after they were cut down.

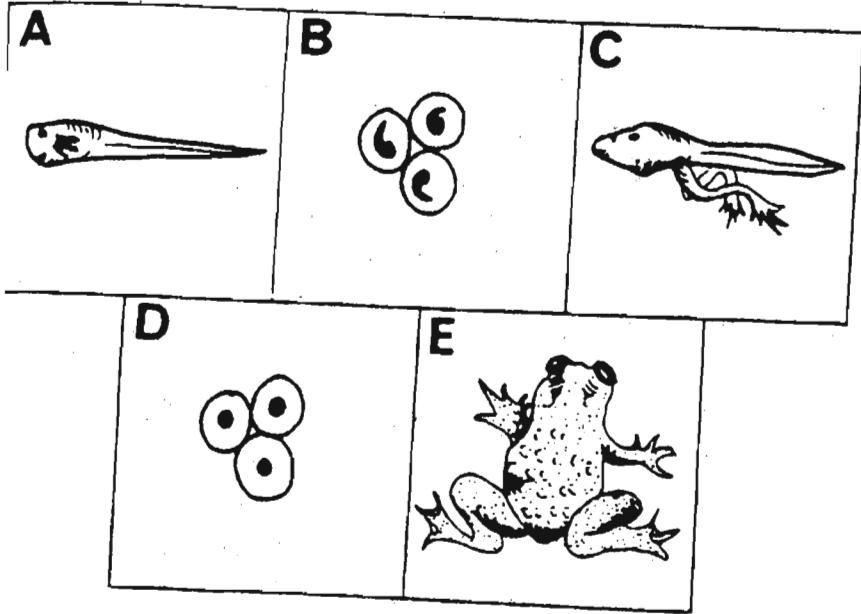


What do you notice about the heights of the trees and the rings in the trunks? (max.)

The taller (bigger) the tree, the more growth rings it has (✓)  
or The tallest tree had most rings, the smallest (✓)  
or Single statement - the shortest tree has fewest rings (✓)

### Question 5

are all stages in the life of a frog, but they jumbled up.



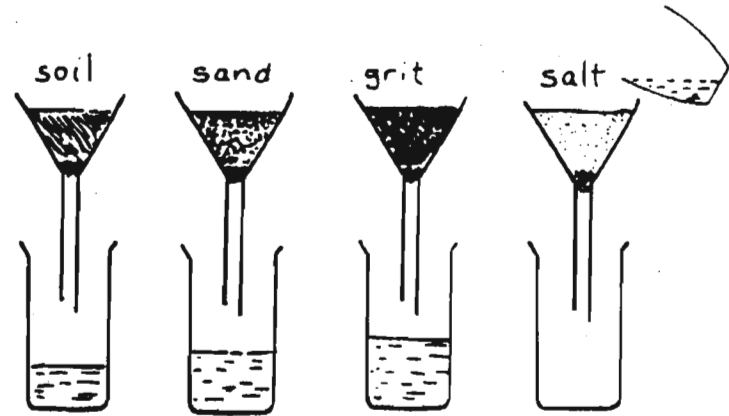
the letters of the pictures in the order in which happen

D, B, A, C, E ✓

### Question 6

David and John put equal amounts of dry sand, soil, grit and salt in four funnels. They wanted to find out how much water each one would soak up. So they poured 100 ml of water into each one.

This worked all right until they came to the salt. When they poured the water in almost all the salt disappeared.

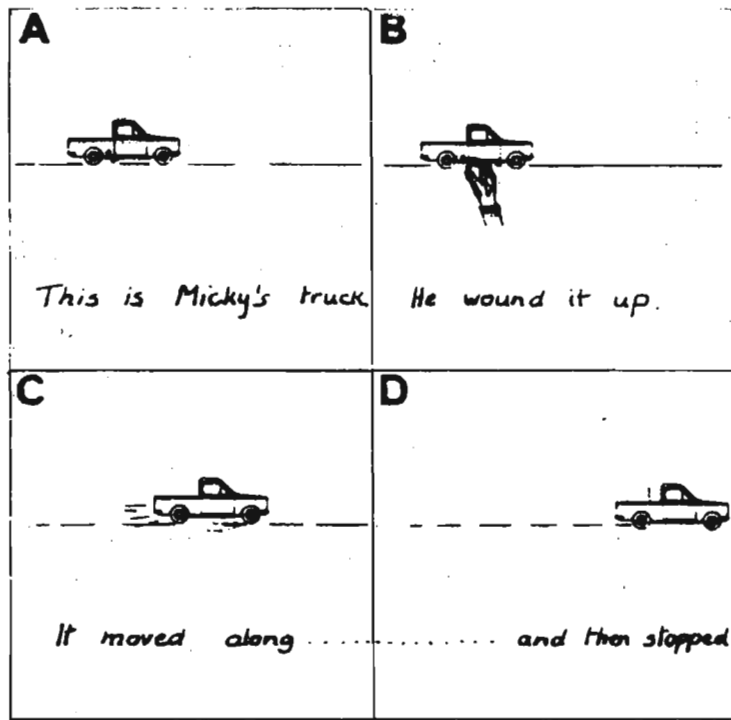


Why do you think the salt disappeared but the other solids did not?

I think this might be because salt dissolves (melts) (goes into) in water, but the other solids do not dissolve in water. (salt carried away in the water)

(max 3)

# Question 7



When did Micky's truck have the most energy?  
Tick in the box next to the one you choose.

- A Before it was wound up
- B After it had been wound up
- C When it was moving along
- D When it had stopped
- Same all the time

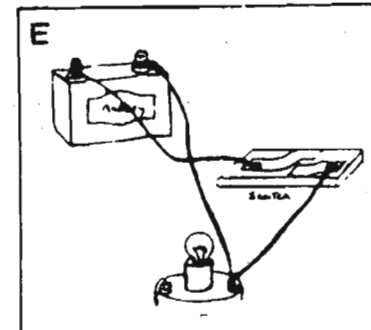
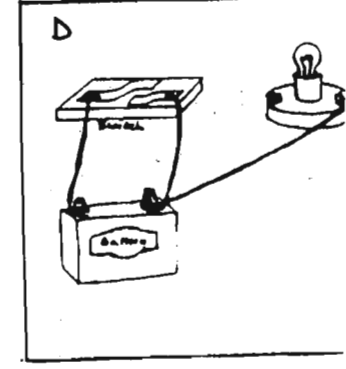
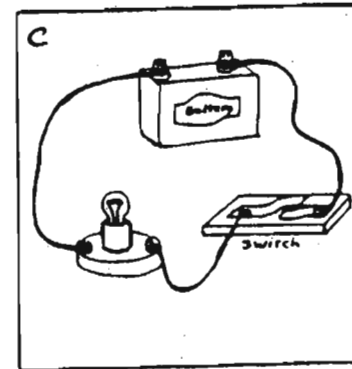
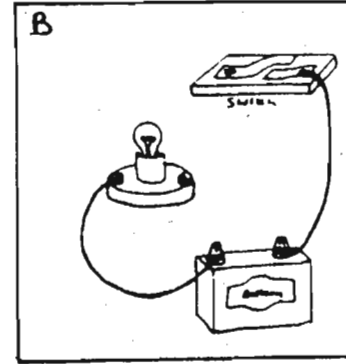
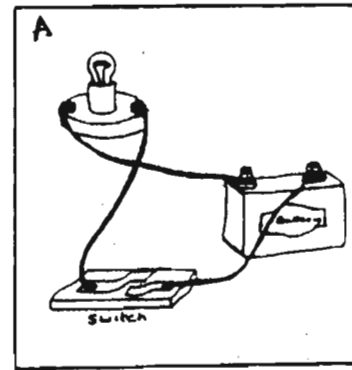
Give the reason for choosing the one you did.

Because - statement to the effect that winding gives car energy and all the rest of the time it is losing energy. ✓

• statement which is correct, but incomplete e.g. (you have to wind it to make it go) ✓

(max 3)

In some of these drawings the wires are connected so that the bulb will light up when the switch is pressed. Put a tick under all the drawings where you think the bulb will light up. (A+C only)(max

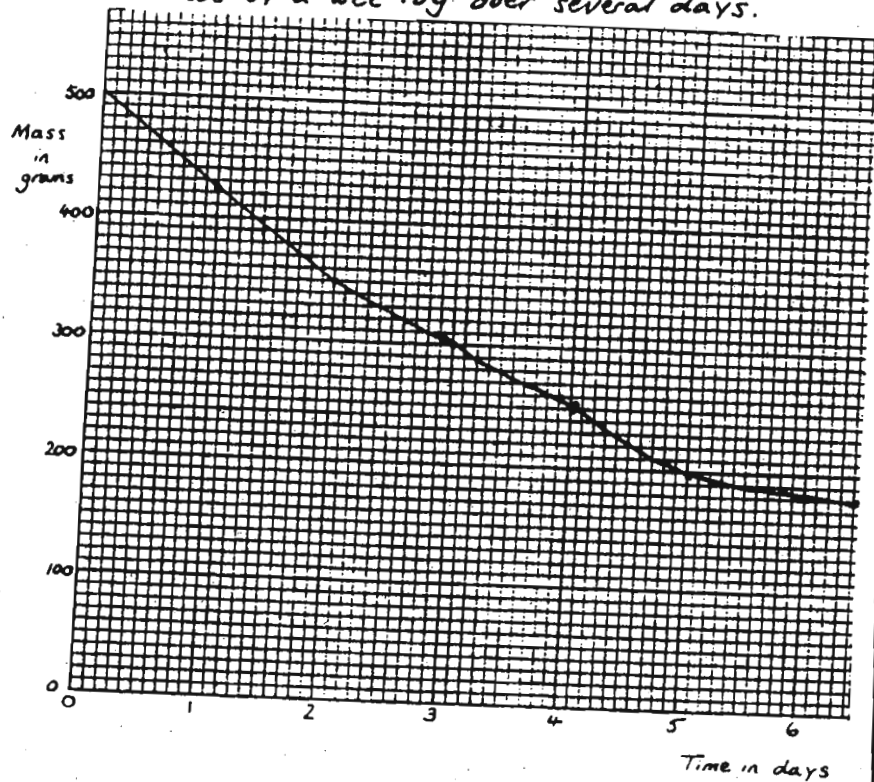


Question 8

### Question 3

Simon was finding out about the amount of water in a wet log of wood. He found the mass of the log when it had been soaked in the rain. He kept it indoors and found its mass each day. This is what he found:

Mass of a wet log over several days.



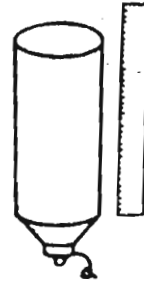
The masses for the next three days were:

- 4th day 250 g ✓
- 5th day 200 g ✓
- 6th day 180 g ✓

+1 for points joined by straight line

Mark these on the graph.

### Question 4



Some children cut the bottom off a washing-up bottle and turned it upside down. They put water in it to 15 cm above the neck and timed how long the water took to run out. They did this again with water up to 12 cm, then 9 cm and 6 cm. They put their results in this table:

Height of liquid in cm	Time to empty in seconds		
	Tap water	Soapy water	Washing up liquid
15	55		
12	40		68 ✓
9	28	25 ✓	
6	20		
3	15 ✓		

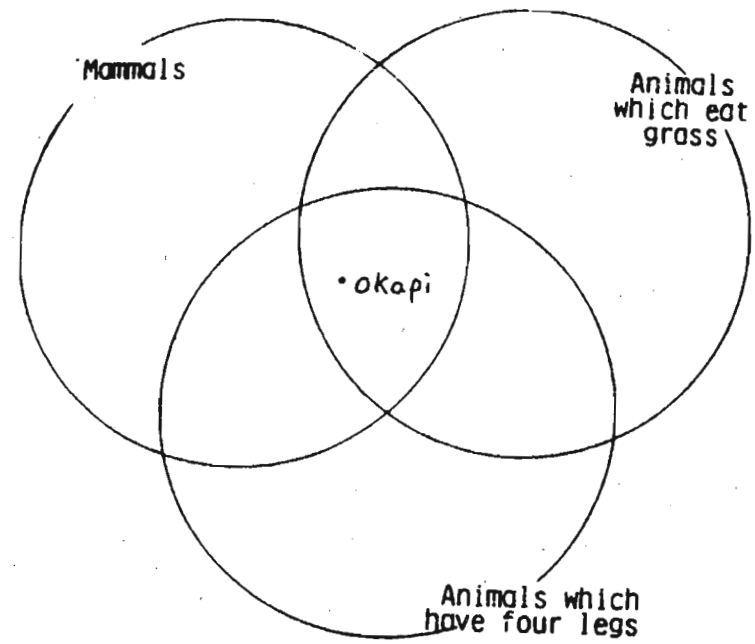
Put these other results in the table:

With soapy water in up to 9 cm it took 25 seconds.

With washing up liquid in up to 12 cm it took 68 seconds.

With tap water in up to 3 cm it took 15 seconds.

Question 1



Write down all that you can tell from this diagram about what sort of animal an okapi is:

- ..... It is a mammal. ✓
- ..... It eats grass - (herbivore) ✓
- ..... It has four legs. ✓
- .....
- .....
- .....

Question 2

To grow butterflies, you need their eggs and their food, and a cage to keep them in. (The food must be fresh).

There is some more information about different kinds of butterflies below.

Butterfly	Food Plant	Egg Colour	How many Days for Eggs to Hatch	Colour of Caterpillar	Colour of Pupa
Small Tortoise-shell	Nettle	Green, then black	5	Black with white flecks	Black, brown or green
Common Blue	Bird's Foot Trefoil	Pearl white	10 - 15	Green with brown line	Green
Swallow Tail	Fennel	Yellow, then brown	6	Black with white marks	Green then brown
Painted Lady	Spear Thistle	Pale green	7	Grey-black	Grey or green
Camberwell Beauty	Willow, Sallow	red-brown	7	Black with red blotches	Brown

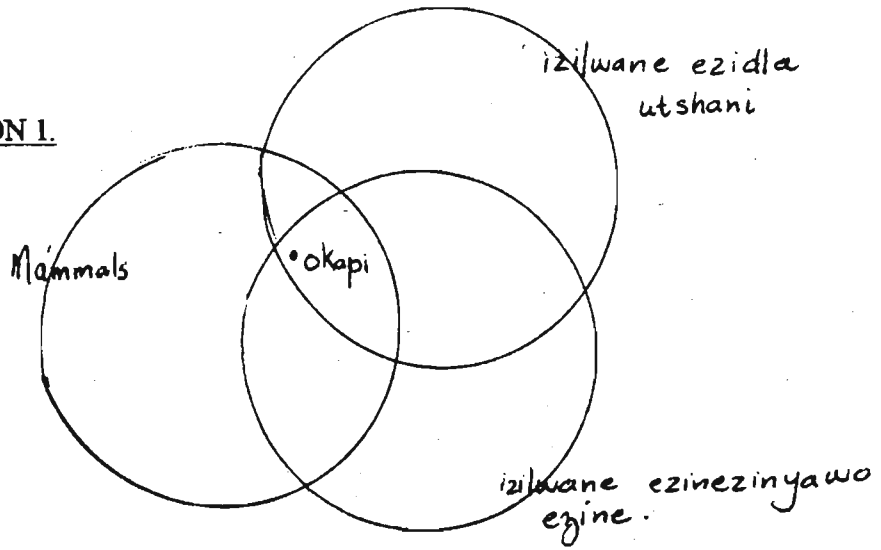
Use the table to help you to answer these questions:-

- a) What is the food plant of the Swallow Tail Butterfly?  
..... Fennel. ✓
- b) Which butterfly's eggs take longest to hatch?  
..... Common Blue. ✓
- c) One butterfly lays red-brown eggs. The colour of its pupa is Brown. ✓

**APPENDIX 2.**

**SKILLS ASSESSMENT USING APU QUESTIONS - ZULU TEST.**

QUESTION 1.



Bhala phansi konke ongakubona kulesisithombe okushoyo ukuthi isilwane esinjani i okapi.

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**QUESTION 2.**

Ukuze sikulise uvemvane sidinga amaqanda nokudla kwawo. Nehoko elizohlala kulo.  
(Ukudla kumele kube-fresh )  
Nazi izincazele ngezinhlobo zamavemvane ahlukalukene.

Ivemvane	Ukudla okuyizitshalo	Umbala weqanda	Izinsuku ezingaki ukuze amaqanda ahamisele	Umbala we caterpillar	Umbala we pupa
Small tortoise shell	Nettle	Green, then black	5	Black with white flecks	Black, brown or green.
Common Blue	Bird's Foot Trefoil	Pearl white	10-15	Green with brown line	Green
Swallow Tail	Fennel	yellow then brown	6	Black with white marks	Green then brown
Painted lady	Spear Thistle	Pale green	7	Grey black	Grey or green
Camberwell Beauty	Willow ,Sallow	Red-brown	7	Black with red patches	Brown

Sebenzisa letitafula elingenhla ukuze uphendule lemibuzo.

A)Yikuphi ukudla okudliwa I Swallow Tail imvemvane?

.....  
B)Yimaphi amaqanda ovemvane othatho isikhathi eside ukuba ahamisele?

.....  
C)Uvemvane olulodwa lukeba ired-brown qanda . Umbala we pupa.

.....



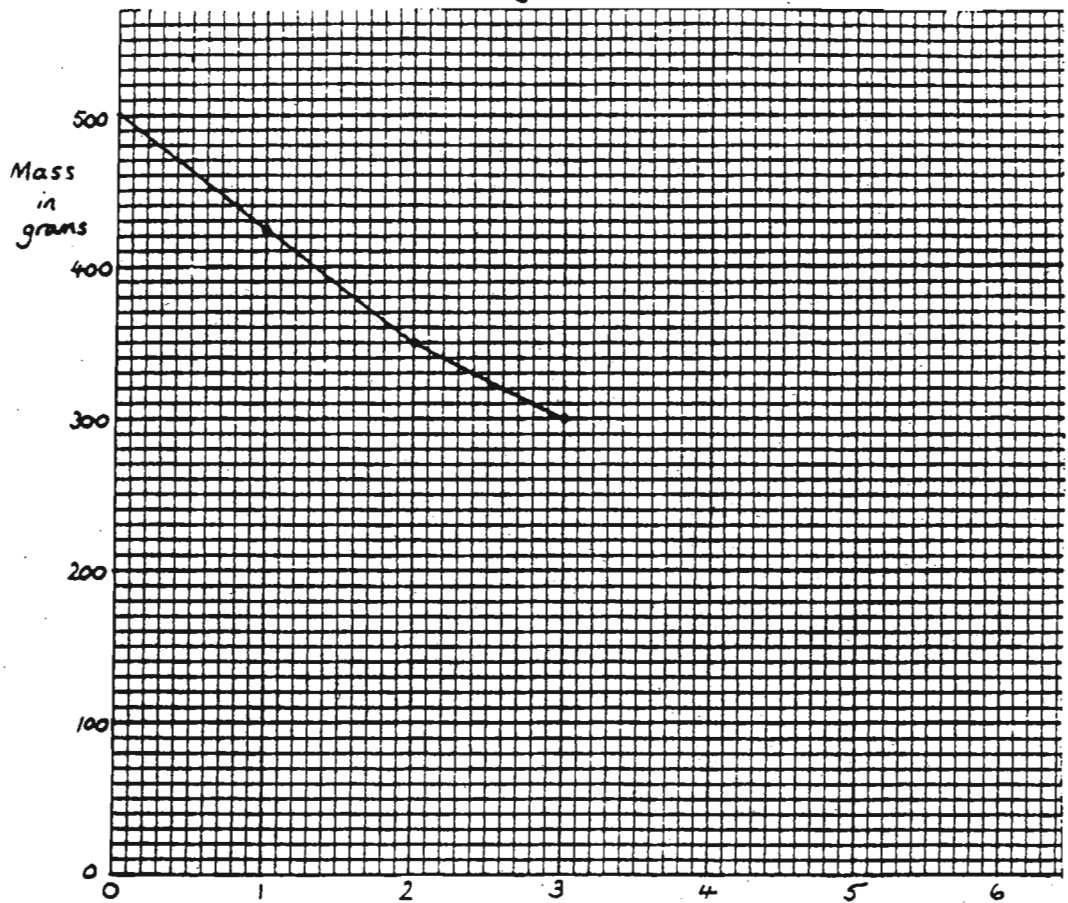
QUESTION 3.

Uvusi wayezama ukuthola kabanzi mayelana nenani lamanzi elisesiqwini sokhuni.

Wathola isisindo sesiqu uma likade licwiliswe emvuleni.

Walubeka ngaphakathi endlini wase ethola aiasindo salo osukwini ngalunye. Yilokhu akuthola.

*Mass of a wet log over several days.*



Izisindo azithola ezintha ezalandela yilezi.

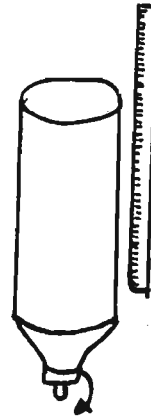
Ngosuka lwesine wathada 250g

Ngolwesihlanu wathola 200g

Ngolwesithupa 180g

Kurveze lakhu kwi graph.

**QUESTION 4**



Ezinye izingane zasika ingaphansi lebhodle la lokuwasha balibhekisa phansi. Bafaka amanzi ukulona angango 15 cm ngaphuza komqala. Kwathatha isikhathi esingakanami ukuthi amanzi aphume. Ba phinda benza into efanayo kodwa amanzi ayegu 12 cm, ehla aya ku 9 cm no 6 cm. Babeka imiphumela yabo kuletable.

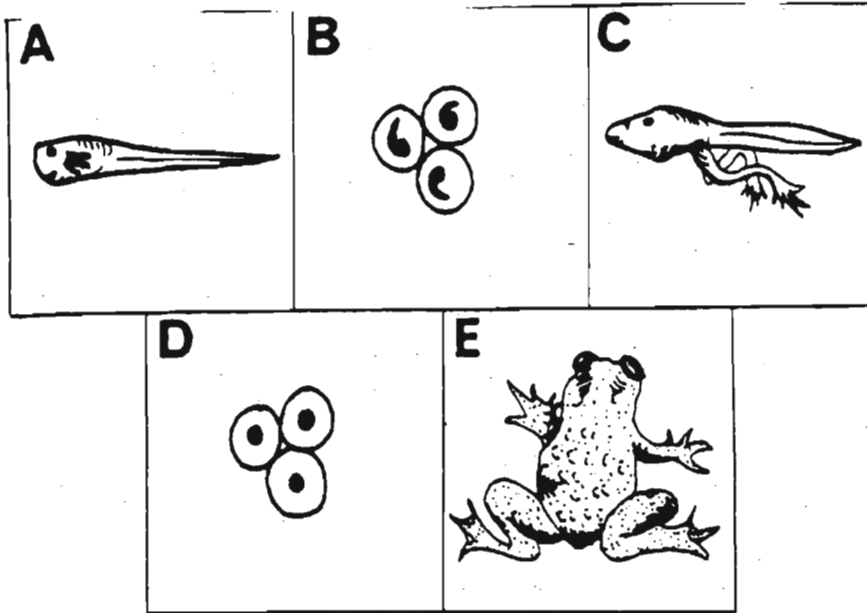
Ubude bamanzi ku ma cm	Isikhathi sokukhipha	ngamasekhondi	
	amanzi ompompi	amanzi anensipho	amanzi okuwasha
15	55		
12	40		
9	28		
6	20		
3			

Faka imiphumelo kuleli tafula.

1. Amanzi anensipho afika ku 9 cm kuthathe amasekhondi angu 25.
2. Amanzi anoketshezi lokuwasha afika ku 12 cm, kuthathe amasekhondi angu 68.
3. Ngamanzi ompompi afika ku 3 cm, kuthatho amasekhondi angu 15.

QUESTION 5.

Lezi izigaba zempilo yexoxo, kodwa zixubekile zama ukuthi ngendlele.



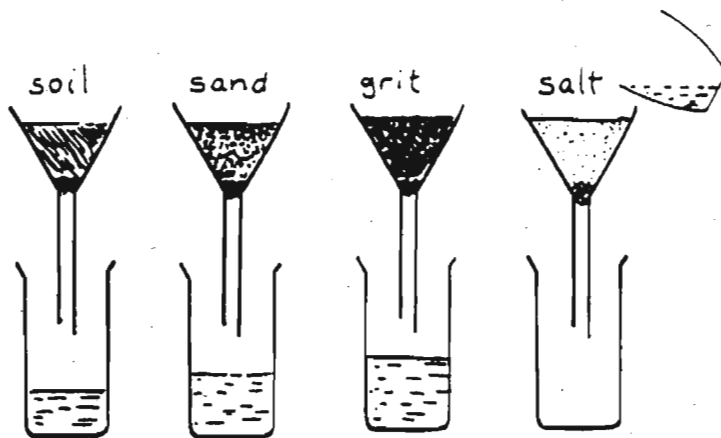
Bhala osongamisa njengendlela izigaba zenzeka ngayo.

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QUESTION 6.

Usandile no Hector bofaka inhlabathi ntshlabathi no sawoti okulinga nayo kumafanele amane. Babefuna ukubona ukuthi lenzinto zazizothatha amanzi ama ngakanani. Base befaka amanzi angango 100ml kwifanele ngayinye.

Kwabasebenzela kahle baze bafika kusawoti. Bathi befaka amanzi kusawoti kodwa usawoti wa nya malala.



Yini ekwenza ucabange ukuthi usawoti wanyaamalala kodwa lokhu okunye okuzange ku nya malale.

Ngicubanya ukuthi lokhu kunyaba, nyoba

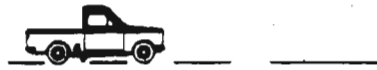
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QUESTION 7.

A. Lena iloli ka Thabani.



B. Uyiphakamisile



C. Iyahamba



D. Yase ima



Iloli ka Thabani ibenini nomdlandla? Beka umaka eceleni kwe bhokisis olikhethileyo.

- A. Ngaphambi kokuba aliphakamise
- B. Ngemva kokuba eseliphakamisile
- C. Ngesikhathi belihamba
- D. Ngemva kokuma kweloli
- E. Ngasosonke isikhathi

Bhala isizathu esenze ukuthi ukhethe le oyibhalile.

Ngoba

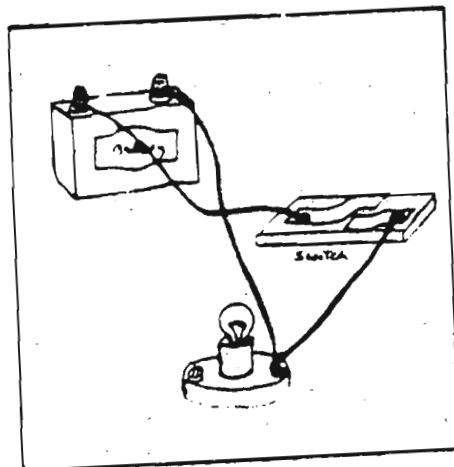
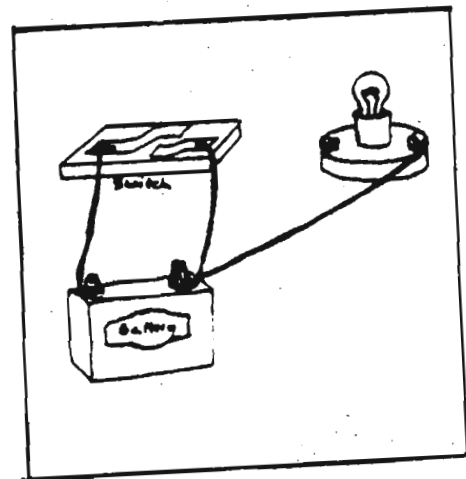
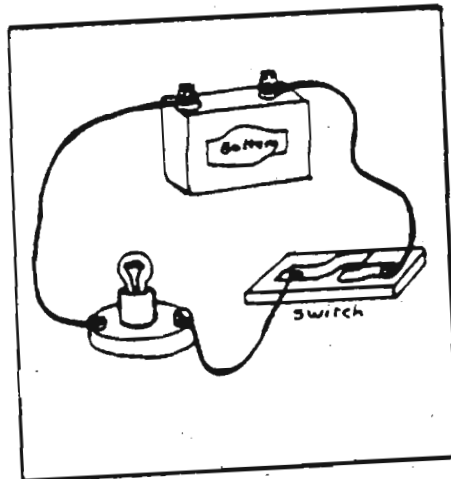
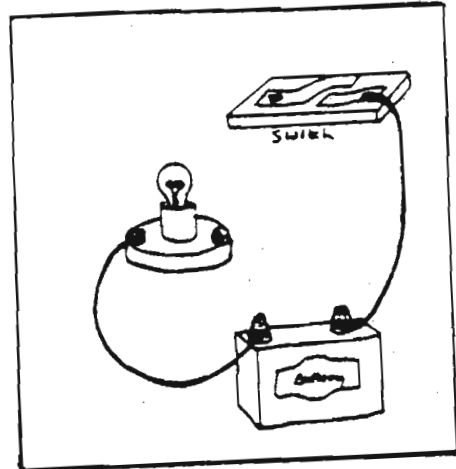
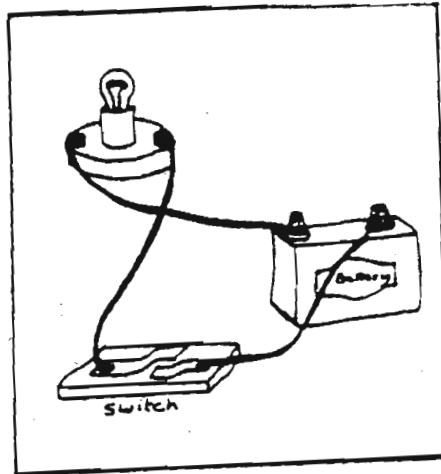
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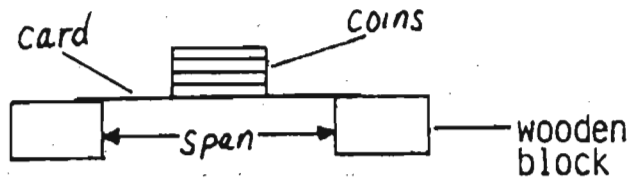
QUESTION 8.

Kweminye imidwebo ucingo laxhunyiwe ukuze ilambu likhanye uma iswishi icidezelwa. Kaka umaka kuyo yonke imidwebo ocabanga ukuthi izokhanya.



**QUESTION 9.**

U-Xolani wakhe imodeli ye blogho ngama amabili okhuni nekhadi.



Wakala indawo ngama sentimitha (cm) wabala izinombolo zenhlweza ezimbili wabhala isibalo so 2c leliblogho elinganawabeko.

Nankuke umphumela.

Indawo yama cm	inombolo yo 2c.
10	5
18	1
12	4
16	2
14	3

a)Iyiphi iphethi oyinothisayo phakathi kwezikhala zama cm inombolo yo 2c i-blogho elingakwezi ukhzisapotha.

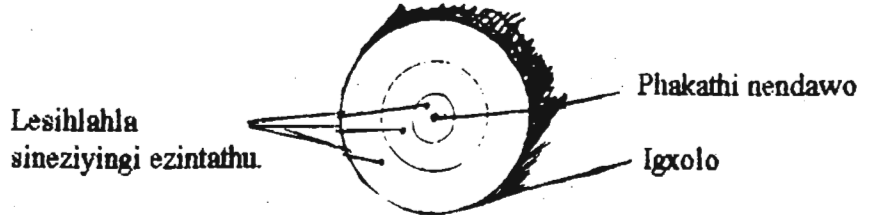
Iphethin engiyikethile \_\_\_\_\_

b)Bangaki o-2c ocabanga ukuthi leli bhulogho elingakwazi ukuyibamba uma isikhathi singu 8cm?

Ngicabanga ukuthi ibridge lingabamba ..... 2c abangu.

QUESTION 10.

Uma sisika isihlala phakathi nendano, sibona iziyingi.



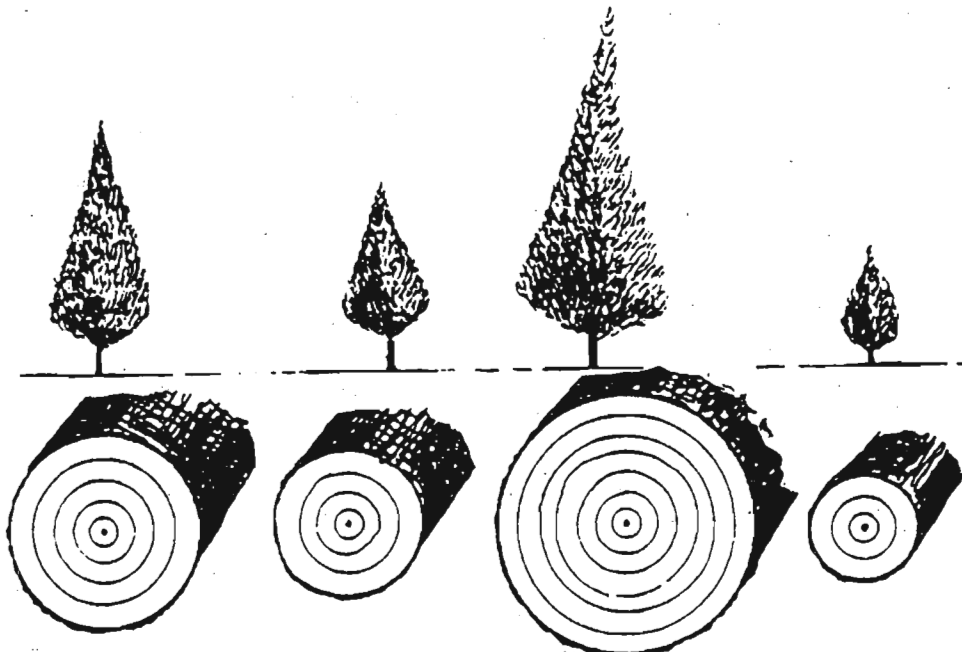
Izihlahla esingezansi zatshalwa ngezikhathi ezihlukene, esikhuni esisoda. Imidwebo I khombisa izihlahla zihlahla zingakasikwa, ngezansi eziyingi zibonqkala sezinqunyiwe.

Yini oyiqaphelayo ngobude bezihlahla kanye neziyingi eziphakathi?

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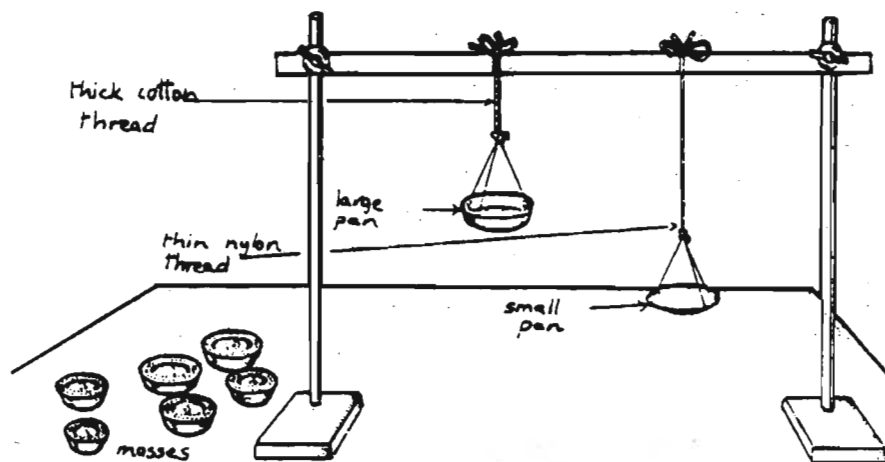
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QUESTION 11.

Petrus beno Zama bebefuna ukoba ukuthi yini ena mandla bakathi kwe nylon no kotini. Benza kanje.



Bafaka isisindo ema pani. Bebefuna ukuthola ukuthi isisindo esingakanani esidingekayo kuqhamsa ukotini.

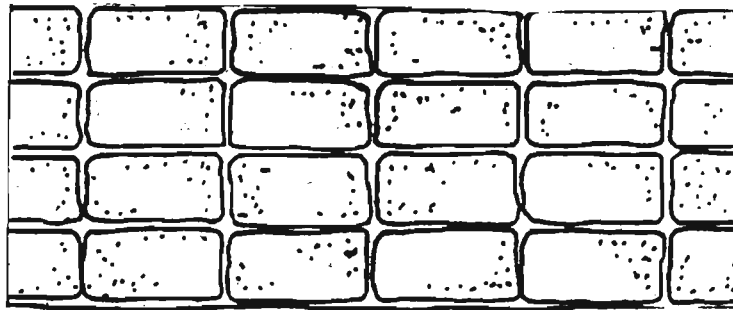
Akusisona isivivinyo esikahle.

Bhala phansi izizathu ezintathu ezizokwenza lesivivinyo sibe eseqiniso.

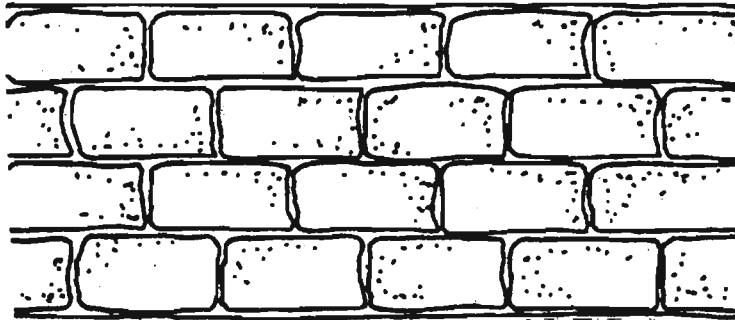
1. \_\_\_\_\_  
\_\_\_\_\_
2. \_\_\_\_\_  
\_\_\_\_\_
3. \_\_\_\_\_  
\_\_\_\_\_

QUESTION 12.

Umichael wakha 'udonga' esebenzisa amabhokisi njenge zitini, kanje:



Uderrick wakha olwakhe udonga ngamabhokisi afanayo, kanje:



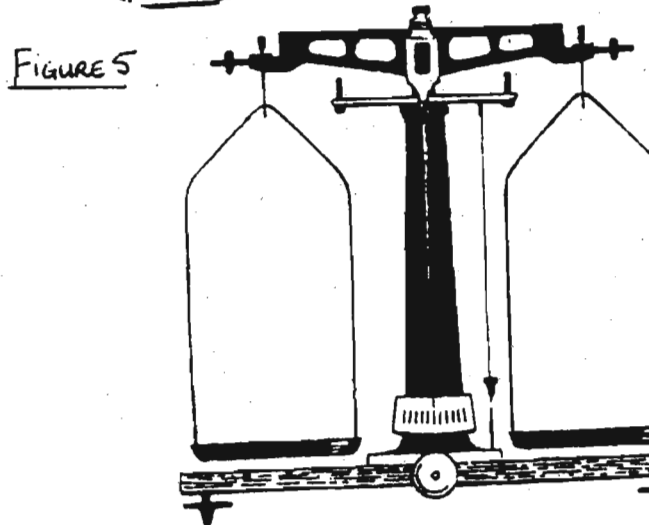
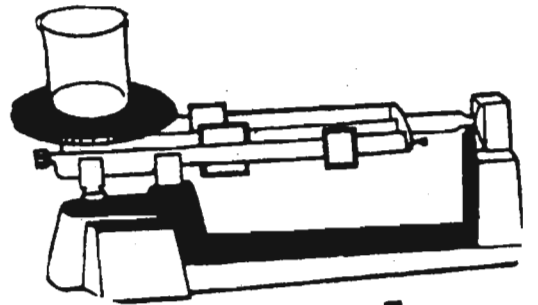
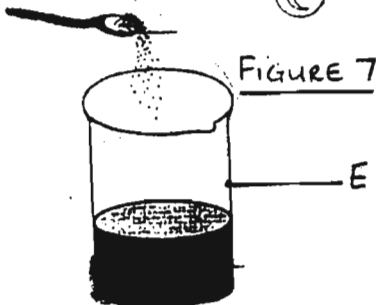
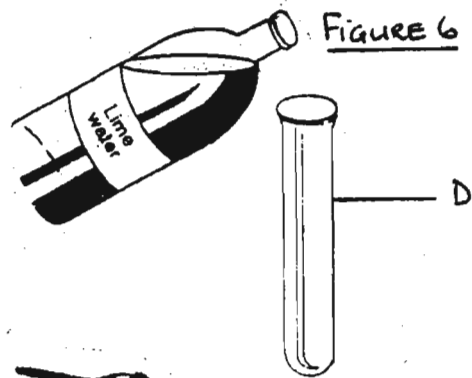
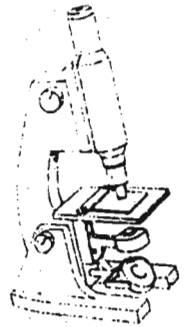
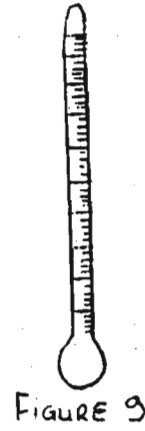
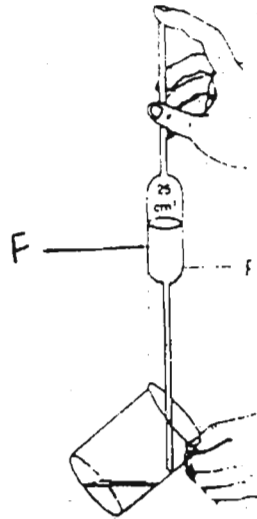
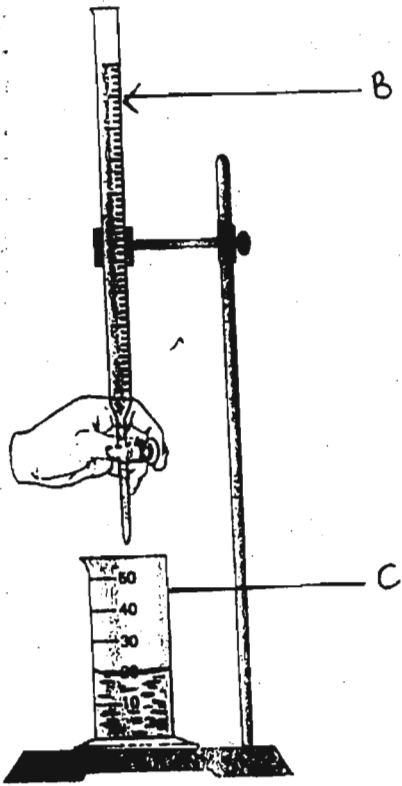
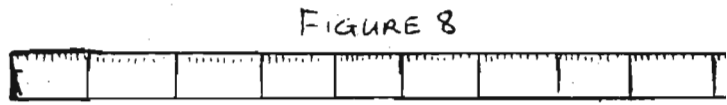
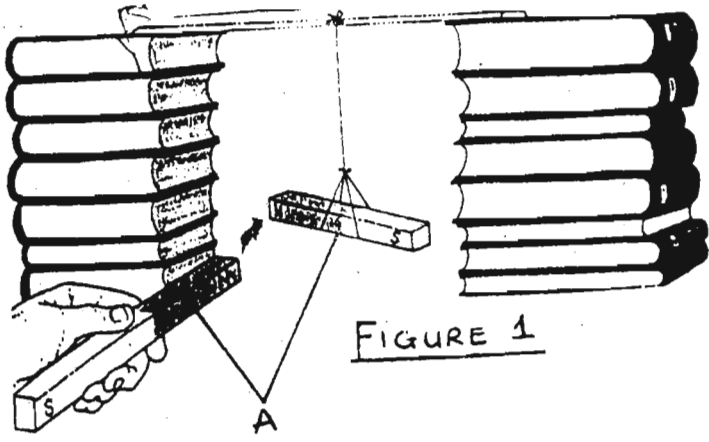
Babe fina ukubona ukuthi uluphi udonga ulunamandla. Bacabanga ukuthi bagikqe amabhola phansi ukuyoshaya udonga. Ukwenza le test ilingane kwakufanele babeke izinto ezifana yo nalezi I ndonga zombili.

Bhala phansi izinto ezu 3 ocabanga ukuthikufanele zibekwe ndawonye.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

**APPENDIX 3.**

**CONTENT ASSESSMENT TEST- SCIENCE CONCEPTS AND EQUIPMENT.**



NAME: Memorandum  
STANDARD: .....  
DATE OF BIRTH: .....  
LAST SCHOOL ATTENDED: .....

The questions below refer to figures 1 to 10 on the diagram sheet. Fill in the answers on this question paper.

**FIGURE 1.**

- a) The objects labelled A are called magnets  
b) N represents (stands for) North and S represents South  
c) The objects will move away from each other.

**FIGURE 2.**

- d) B represents a burette  
e) C is called a measuring cylinder  
f) How much liquid is in part C? 20 ml / 20 cm<sup>3</sup>

**FIGURE 3.**

- g) F is called a pipette  
h) How much liquid would it be able to hold when it is full? 25 cm<sup>3</sup>

**FIGURE 4.**

- i) This instrument is called a Microscope  
j) It will be used to look at small objects - make them bigger (magnify)

**FIGURE 5.**

- k) These diagrams show different types of scales / balances  
l) They are used to measure mass

**FIGURE 6**

- m) D is called a test tube

**FIGURE 7.**

- n) E is called a beaker

**FIGURE 8.**

- o) This instrument is called a metre stick / tape measure / ruler and it is used to measure the length (cm) of an object.  
p) Give the exact measurement of this line segment XY below.

x-----y 6.5 cm.

**FIGURE 9.**

- q) This instrument is called a thermometer and it will be used to measure your temperature

TOTAL: 20

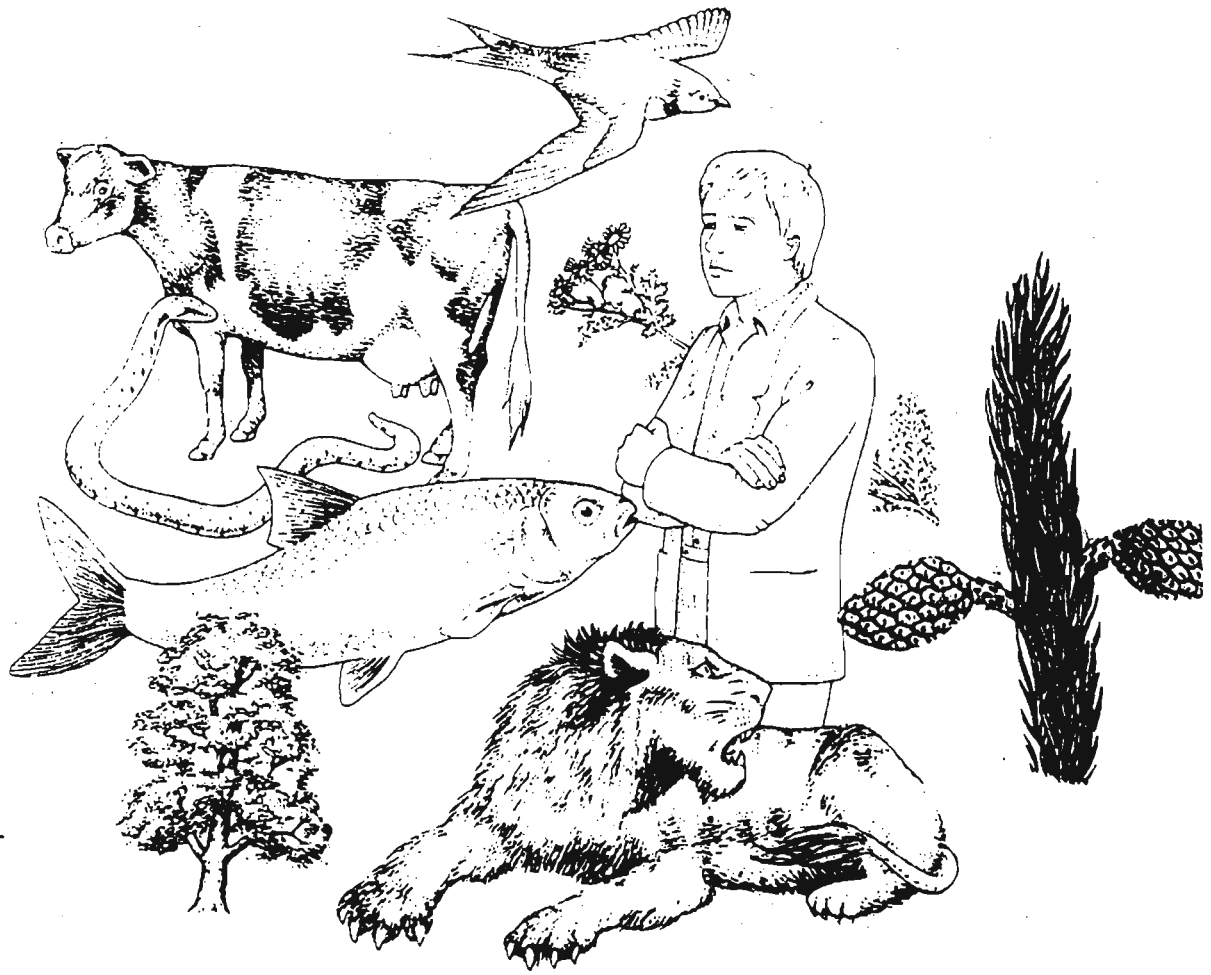


FIGURE 10

Name: Memorandum  
Standard: .....  
Date of Birth: .....  
Last school attended: .....

The questions below refer to figure 10 on the diagram sheet. Answer the questions on this sheet.

**FIGURE 10.**

A) Say whether each of the organisms (things) in the diagram are living or non-living.

Cow living ✓  
Fish living ✓  
Tree living ✓  
Bird living ✓  
Flowers living ✓

b) Name 2 mammals shown in the diagram.

cow / lion ✓ man ✓

c) In this diagram, the tree is the habitat of the bird ✓

d) The lion is a carnivore and a predator. What does this mean? Explain in your own words.

Eats meat / flesh and hunts live prey ✓

e) What parts of the fish would be used for locomotion?

fins ✓

f) The cow eats mainly grasses so we call it a herbivore ✓

g) Man, however, eats both plant and animal material and is therefore called a

omnivore ✓

h) What causes the tree to grow taller each year? ✓

water + mineral salts from the soil,  
food from photosynthesis (uses air (O<sub>2</sub>) and sunlight)

i) Which of the animals in the diagrams lay eggs? fish / snake / birds (any 2)

j) How will the cow feed her young babies (calves)?

suckle her calves - milk from mammary glands.

k) The bird needs lots of energy to fly long distances. Where does it get its energy from?

from the food (seeds etc) that it eats ✓

m) Is Man a vertebrate or an invertebrate? vertebrate, ✓

Give a reason for your answer skeleton with a backbone ✓

n) The parts labelled S are called cone ✓ and will be found

on pine ✓ trees.

TOTAL 25.

**APPENDIX 4.**

**STANDARD 5 TEACHERS' QUESTIONNAIRE.**



**QUESTIONNAIRE: STANDARD 5 GENERAL SCIENCE TEACHERS.**

1. Each teacher's response will be treated with the utmost confidence.
2. When there is an option offered in the questionnaire, please place a cross in the appropriate box.

**SECTION A: GENERAL INFORMATION.**

1. Age this year:

20 -25	26-30	31 -39	40 -45	46-50	51 -60
--------	-------	--------	--------	-------	--------

2. Gender:

MALE	FEMALE
------	--------

3. Qualifications:

- a) Professional. (e.g. HDE,PTD \_\_\_\_\_)
- b) Academic. (STD IO, B.Sc \_\_\_\_\_)

4. School teaching experience (years):

- a) Total. \_\_\_\_\_
- b) General Science. \_\_\_\_\_

**SECTION B: SCIENCE "ENVIRONMENT"**

1. How many General Science periods are allocated to each std 5 class per week (or cycle e.g. 7 day cycle)?

2. How many General Science std 5 classes do you teach per week (or cycle)? \_\_\_\_\_

3. What is the total number of pupils in each class group that you teach.

CLASS GROUP(e.g. 5A)	NUMBER OF PUPILS

4. Which General Science textbooks are used by:

Teacher: \_\_\_\_\_

Pupils: \_\_\_\_\_

5. Did pupils have to share textbooks?

YES	How many per book	NO

6. Do you have any subject contact, via formal discussions, with high school science teachers?(yes/no)

7. Do you have subject contact, via formal discussions, with other primary school science teachers? \_\_\_\_\_

8. Have attended workshops held for primary school science teachers within the last 3 years? \_\_\_\_\_

9. Who hosted these workshops?

Departmental	PSP	Teacher Unions	Colleges	Other (name)

10. Does your school have a laboratory? \_\_\_\_\_

**EQUIPMENT:**

Please indicate in the table below which of the following equipment is available for use in your school. Place a tick in the appropriate column.

Equipment	Enough for pupil use	Enough for demo only	Yes, but broken	NO
Test Tubes				
Beakers				
Measuring Cylinders				
Magnifying glass				
Mass meter				
Metre stick				
Microscope				
Thermometer				
Magnets				

**LANGUAGE POLICY :**

What language usage did you find benefitted your pupils most when teaching?

	English only	Zulu only	Mainly Zulu, with some English.	Mainly English, with some Zulu
Explaining concepts				
Notes and worksheets				
Tests				
Remedial work on tests				
Informal discussion				

**CONTENT COVERED.**

Teachers often find that they are not able to cover all sections of a particular syllabus in any one year, usually because of conditions affecting the school year. Which of the sections

of the standard 5 syllabus did you find that you were able to teach last year, (or the last time that you taught std5).

Section	Whole section	Only some parts	Not covered
Matter and measurement			
Energy+Transfers			
Forces of attraction and repulsion			
Magnetism			
Acids+Bases			
Invertebrate animals			
Vertebrate animals			
Algae			
Fungus			
Fern			
Cone-bearing plants			
Flowering plants			
Sorting and classifying			
Natural resources			

### PROJECTED SKILLS

What percentage of your standard 5 pupils (94/95) do you think were able to successfully accomplish each of the following tasks by the end of standard 5? The percentages in the columns represent the proportion of the class that you think can accomplish each of the tasks.

Task	More than 50% (half)	About 25% to 50	10% or less.
Make a clear diagram from a specimen supplied.			
Measure (in mm) a straight line			
Calculate the area of a square or rectangle			
Tabulate differences between two objects			
Plot points on a graph(e.g. growth measurements)			
Make predictions from data supplied			
Recognise the order in which a sequence of events takes place.			
Write up the results of an experiment conducted in the classroom.			

Thank you very much for your co-operation.

**APPENDIX 5.**

**STANDARD 6 TEACHERS' QUESTIONNAIRE.**

QUESTIONNAIRE. (STD 6 TEACHERS)

Please answer the questions in the spaces provided. It would be most helpful if the views expressed are those that have arisen out of your personal teaching experience.

1. How many years have you taught science (general science, biology or physics)?
2. How much of this time has involved teaching standard 6 general science?
3. Can you complete the table below with regard to the basic skills you expect standard 6 pupils to possess on entry to secondary school.

Skills they ought to possess	Skills they DO possess	Skills mostly absent

4. Apart from the lack of fluency in English, have you found any other difficulties in teaching science to second language pupils?

---

---

---

5. Have your teaching methods in the classroom changed to accommodate second language science pupils. Please elaborate where possible?

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---

6. Please complete the following sentence as fully as possible:

BY THE END OF STD.6 I THINK A SCIENCE PUPIL SHOULD BE ABLE TO

---

**APPENDIX 6.**

**INFORMATION AND QUESTIONS FOR GROUP DISCUSSION WITH**  
**SCIENCE TEACHERS AT THE RESEARCH SCHOOL.**

## SCIENCE ASSESSMENT STD. 6 1996 (B.A.DAMONSE)

1. A content test was administered to all std. 6 pupils at the end of January.
2. A skills- based test was administered to all the same pupils in February. Questions were set testing skills in the following areas. Tests were set in English and Zulu.

- **Symbolic representation:** this included reading information supplied in the form of tables a venn diagram, plotting points on a graph and adding information to a table.
- **Applying science concepts:** use of science based concepts to explain, decide on sequence, say what will work etc.
- **Interpreting presented information:** includes finding patterns, making predictions, drawing conclusions.
- **Planning parts of investigations:** control of variables, procedure, criticism of methods.

### RESULTS:

1. The skill areas tested are very poorly developed in **all pupils**. Examine some of the histograms supplied to judge the extent of the absence of these skills at this level. The percentage of non-response was alarming.
2. Language does not seem to have had a significant difference in performance. The one area in which there seems to be a difference in performance between Zulu pupils taking the test in Zulu and in English is in the area of application of science concepts.
3. Students generally have had very little exposure to scientific equipment, even the simplest types e.g. test tubes and beakers.
4. Basic science concepts( such as the difference between living and non-living, the term energy etc) are very poorly developed.
5. Use of various terms that we teachers take for granted does affect performance on content based tests---words like habitat, locomotion, line segment.

### TOPICS FOR DISCUSSION.

- Comment on test/results of tests.
- Proposals for intervention/ what do we do in our situation?
- What about the forthcoming skills based std 7 examination? Does the responsibility now shift to the std.7 teachers?
- To what extent do you think we teach/ are able to teach, the required science skills in our daily science teaching.

**APPENDIX 7.**

**MEAN SCORES ATTAINED BY STANDARD 6 PUPILS IN a) EACH  
QUESTION AND b) EACH CATEGORY IN THE SKILLS ASSESSMENT.**



**Estimated mean scores (expressed as raw scores and percentages) for the skills assessment of the standard 6 pupils at the research school.**

<b>QUESTION</b>	<b>TOTAL SAMPLE</b>	<b>ENGLISH TEST - L1 PUPILS</b>	<b>ENGLISH TEST-L2 PUPILS</b>	<b>ZULU TEST-L2 PUPILS</b>
Q.1.	0.49 (16%)	1.05 (35%)	0.34 (11%)	0.828 (28%)
Q.2	1.4 (47%)	2.3 (79%)	1.1 (37%)	1.19 (40%)
Q3	0.08 (2%)	0.3. (18%)	0.004 (0.1%)	0.03 (0.75%)
Q4	0.4 (13%)	0.7 (23%)	0.3 (10%)	0.41(14%)
Q5	0.43 (43%)	0.9 (90%)	0.3 (30%)	0.72 (72%)
Q6	0.21 (7%)	0.7 (23%)	0.08 (3%)	1 (33%)
Q7	0.29 (10%)	0.6 (23%)	0.197 (7%)	0 (0%)
Q8	0.116 (12%)	0.2 (20%)	0.09 (9%)	0.12 (12%)
Q9	0.1 (3%)	0.3 (8%)	0.008 (0.2%)	0 (0%)
Q10	0.23 (8%)	0.7 (23%)	0.09 (3%)	0.18 (6%)
Q11	0.142 (5%)	0.6 (20%)	0.008 (0.2%)	0.08 (3%)
Q12	0.116 (4%)	0.4 (13%)	0.038 (1%)	0.02 (0.6%)

**Estimated mean scores and percentage performance of the standard 6 pupils in each of the skills categories tested.**

<b>CATEGORY</b>	<b>TOTAL SAMPLE</b>	<b>ENG. TEST-LI PUPILS</b>	<b>ENG. TEST-L2 PUPILS</b>	<b>ZULU TEST-L2 PUPILS.</b>
Reading information	0.9 (30%)	1.7 (57%)	0.72 (24%)	1.01 (34%)
Adding information	0.24 (8%)	0.5 (14%)	0.15 (4%)	0.22 (6%)
Science concepts	0.26 (7%)	0.6 (17%)	0.37 (11%)	0.46 (13%)
Interpreting data	0.17 (5%)	0.5 (14%)	0.05 (1%)	0.09 (3%)
Planning investigations	0.17 (4%)	0.5 (16%)	0.02 (0.6%)	0.05 (2%)

**APPENDIX 8.**

**a) CODING SYSTEM USED FOR PUPIL RESPONSES IN THE SKILLS ASSESSMENT.**    **b) NUMBER OF PUPILS WITH EACH CODE IN EACH QUESTION.**

## CODING SYSTEMS USED FOR PUPIL RESPONSES IN THE SKILLS

### ASSESSMENT TEST.

#### QUESTION 1. (3 marks)

- A. Blank
- B. That which is written down is correct.
- C. Lists examples of categories e.g. cow, dog.
- D. Lists characteristics of some or all categories.
- E. Others e.g. definitions of terms, unrelated facts.
- F. Lists items as they are written in the question (rewriting directly from the question paper).

#### QUESTION 2. (3 marks)

- A. Blank
- B. That which is written down is correct.
- C. Reading information from correct column but incorrect row.
- D. Apparent misunderstanding of question(s) e.g. fill in yes or no, colour instead of food, number of days instead of butterfly name, answers that do not appear in the table.

#### QUESTION 3. (4 marks)

- A. Blank
- B. That which is written down is correct.
- C. Plotted correct points but did not join them.
- D. Drew lines (straight or curved), but incorrect points or axes.
- E. Points filled in, incorrect positions, not joined by lines.

#### QUESTION 4. (3 marks)

- A. Blank
- B. That which is written down is correct.
- C. Numbers filled in, but in incorrect places (some or all).
- D. Others e.g. ticks, yes or no, names and explanations.

#### QUESTION 5. (1 mark)

- A. Blank
- B. That which is written down is correct.
- C. Sequence of events is incorrect.
- D. Others e.g. labels, drawings, short explanations.

#### QUESTION 6. (3 marks)

- A. Blank
- B. That which is written down is correct.
- C. Salt is lighter than sand/sand is heavy.

- D. Salt has smaller particles. It is fine/soft/powder.
- E. Others e.g. salt is acid. Explanations not related to the question of WHY?

**Question 7. (3 marks)**

- A. Blank
- B. That which is written down is correct.
- C. Most energy BEFORE the lorry was wound up.
- D. Most energy when the lorry was MOVING.
- E. Others e.g. ticking more than one answer, or choice of D.

**QUESTION 8. (1 mark)**

- A. Blank
- B. Indicated both A and C
- C. Indicated either A or C.
- D. Indicated incorrect circuits (one or more).

**QUESTION 9 (4 marks) and QUESTION 10 (3 marks).**

- A. Blank
- B. That which is written down is correct.
- C. Incorrect relationship stated/ no pattern/ single factors stated.
- D. Partial pattern recognised, though incomplete.

**QUESTION 11 (3 marks).**

- A. Blank
- B. That which is written down is correct .
- C. Stating obvious differences but not suggesting changes to be made.
- D. Incorrect changes suggested e.g. add vegetables, cut with a knife.
- E. Facts stated, not changes to be made e.g. small pans, masses, cotton.
- F. Masses/weights must be the same.

**QUESTION 12 (3 marks).**

- A. Blank
- B. That which is written down is correct.
- C. Alternative tests or suggestions e.g. paint the wall..... windows and wood.....Derrick laughed when the wall fell over.....do it neatly etc
- D. Explanations not clear,related to the building of a wall in general.
- E. Repeat the same factors or information from the question.

**ANALYSIS OF SKILLS ASSESSMENT RESULTS ACCORDING TO CODED**

**PUPIL RESPONSES: ENGLISH TEST RESULTS.**

**Number of pupils with each code for each question. (302 pupils)**

Code	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
A	81	14	221	101	58	82	73	117	168	129	199	217
B	44	91	3	18	131	14	52	33	7	9	7	6
C	88	72	3	177	21	4	29	67	124	132	21	29
D	53	125	70	6	92	29	101	85	3	31	30	40
E	25	0	5	0	0	173	47	0	0	1	33	7
F	11	0	0	0	0	0	0	0	0	0	12	3

**ANALYSIS OF SKILLS ASSESSMENT RESULTS ACCORDING TO CODED**

**PUPIL RESPONSES: ZULU TEST RESULTS.**

**Number of pupils with each code for each question. (186 pupils)**

Code	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
A	21	11	128	33	10	25	28	45	118	84	120	124
B	46	28	1	10	131	41	55	22	0	0	1	0
C	60	45	2	140	18	5	19	34	67	73	24	23
D	28	102	52	2	27	17	62	85	1	29	17	37
E	31	0	3	1	0	74	22	0	0	0	10	2
F	0	0	0	0	0	0	0	0	0	0	4	0

**APPENDIX 9.**

**MEAN PERFORMANCE ESTIMATES FOR 11 YEAR OLDS IN ENGLAND,**

**WALES AND NORTHERN IRELAND.**

**Estimated percentage mean performance estimates for 11 year olds in each of England, Wales and Northern Ireland. (APU 1984 p.288)**

Sub-categories	England	Wales	Northern Ireland
Reading info from graphs, tables and charts	56.6	57.1	61.8
Representing info as graphs, tables and charts.	62.6	64.4	62.0
Interpreting presented information.	32.3	32.2	32.8
Applying science concepts.	30.8	31.8	30.8